San Luis Drainage

FEATURE RE-EVALUATION

Plan Formulation Report

US Department of the Interior

Bureau of Reclamation

Sacramento, California

December 2002

Mission Statement

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

This Plan Formulation Report was prepared pursuant to the District Court's December 2000 Order, under remand from the Ninth Circuit Court of Appeals, stating that the "…Department of Interior…shall without delay, provide drainage to the San Luis Unit, pursuant to the statutory duty imposed by section 1(a) of the San Luis Act." The order also stated that the U.S. Department of the Interior has the authority and discretion to pursue alternatives other than the interceptor drain to satisfy its duty under the San Luis Act. Identification of the proposed action in this report is consistent with the schedule presented in *Plan of Action for Drainage to the San Luis Unit Central Valley Project* (Reclamation 2001c), which stated that a preferred alternative would be identified by December 2002. The next step is to complete the appropriate environmental documentation and engineering studies required for a decision to implement. Although the proposed action will be further developed, refined, and compared to other alternatives during the next phase of study, this report provides the direction that the Bureau of Reclamation proposes to take for providing drainage service. Consistent with the Plan of Action, a Draft Environmental Impact Statement is scheduled for public review by June 2004.

Note: As this Plan Formulation Report was in final production, the Sumner Peck plaintiffs, Westlands Water District, and the United States reached a settlement agreement in the underlying lawsuit (*Sumner Peck Ranch, Inc., et al. v. Bureau of Reclamation, et al.,* Civ. No. F-91-048OWW [U.S. District Court for the Eastern District of California 2002]). As a result of this agreement, the number of acres requiring drainage service in the San Luis Unit will be reduced by approximately 33,000 acres. The alternatives presented in this report will be reformulated to incorporate this change.

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- Ocean Disposal Alternative
- Delta-Chipps Island Disposal Alternative*
- Delta-Carquinez Strait Disposal Alternative*
- In-Valley Disposal Alternative

*Use Delta Disposal Alternatives when referring to both alternatives together

AF	acre-foot or acre-feet
APE	Area of Potential Effect
CFR	Code of Federal Regulations
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act (Title XXXIV of Public Law 102-575)
Delta	Sacramento-San Joaquin River Delta
Drain	San Luis Interceptor Drain, an existing feature of the Central Valley Project that, under the terms of the 1995 Use Agreement with the Grassland Area Farmers, is used to convey agricultural drainwater
dS/m	decaSiemen(s) per meter
DWR	California Department of Water Resources
EES	Enhanced Evaporation System
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ET	evapotranspiration
GDA	Grassland Drainage Area
GIS	Geographic Information System
HDPE	high-density polyethylene
IDC	interest during construction
Interior	U.S. Department of the Interior

m	meter
µg/L	microgram(s) per liter
MBTA	Migratory Bird Treaty Act
mg/L	milligram(s) per liter
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
O&M	operation and maintenance
PAR	*San Luis Drainage Feature Re-evaluation, Preliminary Alternatives Report* (Reclamation 2001a)
ppb	part(s) per billion
ppm	part(s) per million
PVC	polyvinyl chloride
Reclamation	Bureau of Reclamation
Re-evaluation	San Luis Drainage Feature Re-evaluation
Regional Board	San Francisco Bay Regional Water Quality Control Board
RO	reverse osmosis
ROW	right-of-way
Se	selenium
Service	U.S. Fish and Wildlife Service
SJVDP	San Joaquin Valley Drainage Program
State Board	California State Water Resources Control Board
TDS	total dissolved solids
Unit	San Luis Unit (not SLU)
WDR	Waste Discharge Requirements (for example, Regional Board's Order Number 98-171)
Westlands	Westlands Water District (not WWD)

Terminology

drainwater	water leaving an irrigated area, composed of a combination of tailwater, tilewater, ricewater, and possibly canal seepages
Drainwater reduction	a management action or system used to control drainwater; nine options (excluding the No Action Alternative) are listed below for the San Luis Drainage Feature Re-evaluation: • Annual Fallowing – similar to land retirement but implemented on an annual basis by willing parties • Controlled Drainage – controlling the discharges and water depths from subsurface tile drainage systems so that a portion of irrigation deep percolation is retained in the soil and is available to contribute to crop evapotranspiration (ET) • Drainwater Recycling – reapplying drainwater and mixing it with freshwater for crop irrigation • Land Retirement – changing from irrigated to nonirrigated land uses over the long term so that irrigation deep percolation and the need for drainage is totally eliminated on selected lands • On-Farm Irrigation Systems and Management – improving the uniformity and timing of irrigation to reduce deep percolation • Reuse (Reuse/Drainwater Management) – using drainwater as an irrigation supply for salt-tolerant crops • Seepage Reduction – includes lining or piping of existing unlined irrigation conveyance and distribution facilities to reduce seepage losses • Semiconfined Zone Groundwater Pumping – pumping groundwater from aquifers that overlie more impermeable layers • Shallow Drainage – placing subsurface tile drains at relatively shallow depths so that they intercept less and possibly improve the quality of drainwater
ricewater	surface drainwater from the flooding of a rice field
tailwater	surface irrigation drainwater other than ricewater
tilewater	subsurface irrigation drainwater that is discharged through a sump
Water Year	October 1 to September 30 of each year
2001 Use Agreement	Second Agreement for Use of the San Luis Drain (Agreement No. 01-WC-20-2075) (Grassland Bypass Project)

INTRODUCTION

In response to a court *order (Sumner Peck Ranch, Inc. et al. v. Bureau of Reclamation et al.*), the Bureau of Reclamation (Reclamation) is re-evaluating options for providing drainage service to the San Luis Unit (the Unit). The San Luis Drainage Feature Re-evaluation (the Re-evaluation) is being conducted pursuant to Public Law 86-488, which authorized the Unit.

PURPOSE OF THIS REPORT

This Plan Formulation Report sets forth the analysis of alternatives for providing drainage service to the San Luis Unit. The report describes the process of:

- *Refining and evaluating preliminary alternatives*
- *Selecting four final alternatives*
- *Conducting a preliminary impact analysis*
- *Comparing alternatives*
- *Identifying the proposed action*

This report accomplishes the important objective of meeting the Plan of Action milestone for identifying a proposed action by December 2002.

During the next phase of the Feature Re-evaluation process, Reclamation will refine the components of the proposed action, provide additional engineering detail, and complete the environmental review of the proposed action and alternatives.

Background

Reclamation has worked over a long period of time to provide drainage service to the San Luis Unit. As part of a San Luis Unit Special Study in the early 1980's, Reclamation developed plans and cost estimates for completing the San Luis Drain to a point near Chipps Island in the Sacramento-San Joaquin River Delta, an evaporation pond alternative, and a desalting alternative. In 1983, embryonic deformities were discovered in aquatic birds at Kesterson Reservoir. In 1985, following a Nuisance and Abatement Order issued by the State Water Resources Control Board, discharges to Kesterson Reservoir were halted, and feeder drains leading to the San Luis Drain were plugged. Because of the high selenium levels found in the drainage water and the effects at Kesterson Reservoir, the special study was suspended. Since then, Reclamation has been engaged with other State and Federal agencies, as well as farmers, water districts, and other stakeholders, to develop effective, affordable, and implementable drainage solutions. Several of these efforts have resulted in innovative and promising techniques, and Reclamation is committed to continuing to support those approaches.

In 1991, landowners within the Westlands Water District (Westlands) brought suit against the Department of Interior (Interior) alleging that the absence of drainage service had resulted in harm to their lands. As a result of that lawsuit, the court directed Interior to provide drainage service pursuant to Section 1(a) of the San Luis Act of 1960. However, Interior is not necessarily required to construct an interceptor drain. The court concluded the Secretary of the Interior has discretion to identify the affected acres and select the appropriate manner by which to provide drainage service. In accordance with a court order, Reclamation developed a Plan of Action (April 2001) outlining its proposed efforts to provide prompt drainage service considering a variety of options. In December 2001, Reclamation published a Preliminary Alternatives Report, which described a set of preliminary alternatives based on previous studies and proven technologies.

Major Findings

- By 2050, approximately 379,000 acres would need drainage service (343,000 acres in the Unit and 36,000 acres in the Northerly Area outside the Unit).
- Cost-effective, on-farm and in-district drainwater reduction measures and regional drainwater reuse could reduce drainage volumes by nearly 80 percent.
- For land retirement scenarios, it appears that the expected costs of purchasing and retiring lands is greater than the cost of providing drainage service to these lands.
- Implementing any drainage service plan would require further congressional action to increase the authorized appropriation cap under the San Luis Act.

Proposed Action

Based on the evaluation described in this report, Reclamation has identified the In-Valley Alternative as the proposed action. This alternative includes a drainwater collection system, regional drainwater reuse facilities, selenium treatment, reverse osmosis treatment for the Northerly Area, and evaporation ponds for salts disposal.

The In-Valley Alternative has the lowest cost, the shortest time to implement, greatest flexibility to adjust to new technology or changing conditions, and fewest potential impacts to aquatic resources. In the next phase of the Re-evaluation, Reclamation will complete the detailed environmental analysis of these alternatives and publish an Environmental Impact Statement (EIS) identifying potential adverse environmental impacts and potential mitigation.

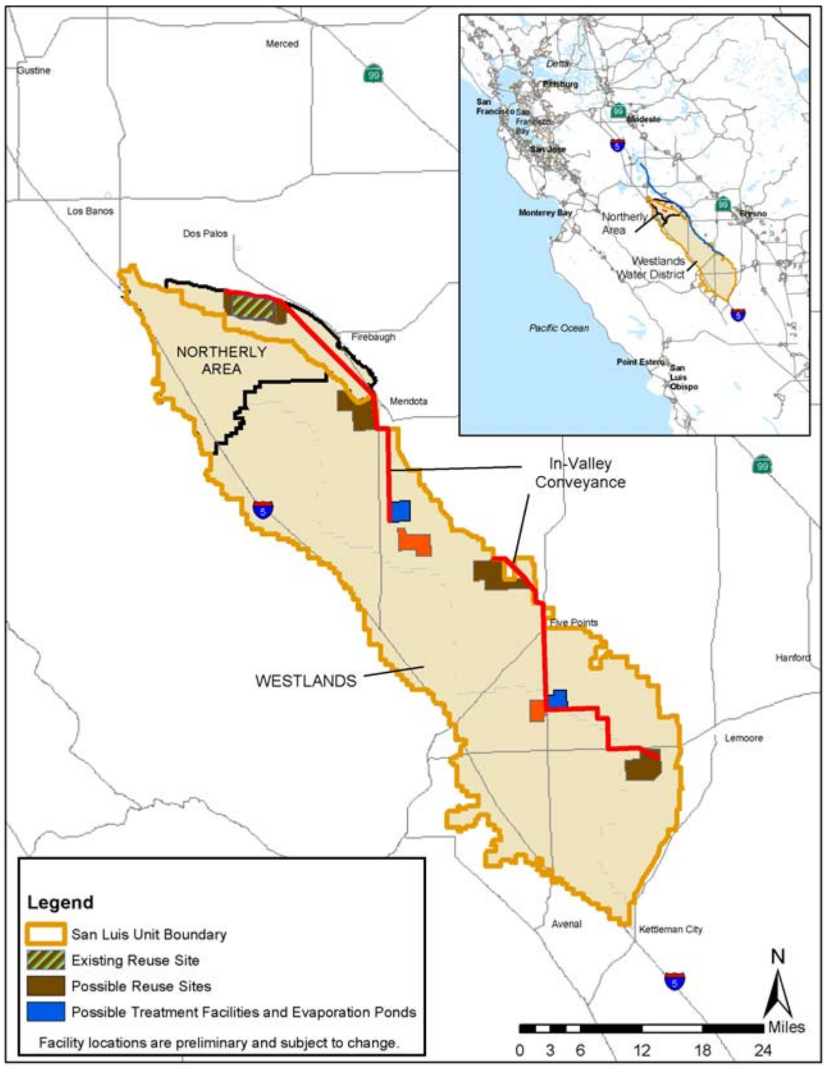


Figure ES-1 Proposed Action

COMPONENTS OF COMPLETE DRAINAGE SERVICE ALTERNATIVES

Before identifying alternatives for providing drainage service, Reclamation defined the components that comprise a complete drainage solution. Reclamation defined the Federal drainage service components to be the collection, treatment, and disposal of drainwater from irrigated farmland (Figure ES-2). To determine the appropriate size of collection, treatment, and disposal facilities, Reclamation identified the lands that would require drainage service and the estimated quantity and quality of drainwater. On-farm or in-district actions, such as irrigation management or seepage reduction, could reduce the volume of drainwater that would be generated. Therefore, Reclamation's plan formulation process identified cost-effective drainwater reduction measures that farmers and/or water districts would be expected to implement.

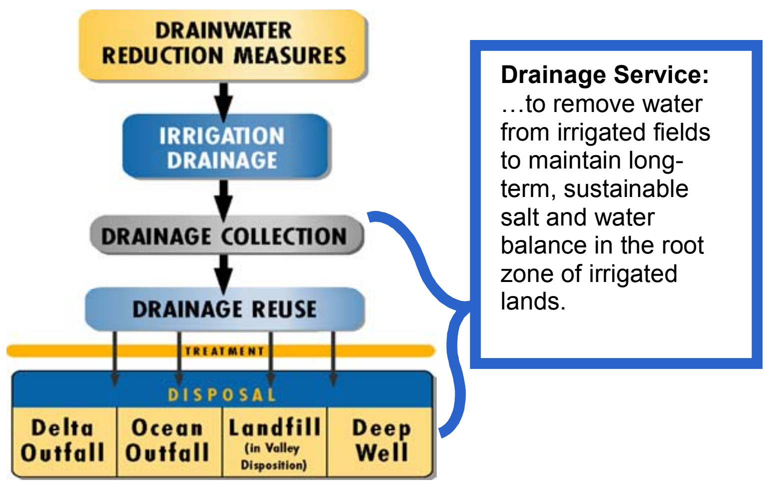


Figure ES-2 Complete Drainage Alternatives

The remainder of this executive summary describes the evaluation process and provides additional details on the proposed action and alternatives:

- Project purpose and study area
- Drainage quantity and quality, including identification of lands requiring drainage service and drainwater reduction measures
- Drainage service alternatives development
- Evaluation and selection of proposed action

The information in this Plan Formulation Report is intended to identify the proposed action, other reasonable alternatives, and the No Action Alternative, and provide the basis for more detailed evaluation in the EIS.

PROJECT PURPOSE AND STUDY AREA

The project purpose is to **provide agricultural drainage service to the Unit that achieves long-term, sustainable salt and water balance in the root zone of irrigated lands**. A long-term, sustainable salt and water balance is needed to ensure sustainable agriculture in the Unit and the region.

The drainage study area is located in western San Joaquin Valley and consists primarily of the lands lying within the boundary of the Central Valley Project's San Luis Unit. The Unit, as defined by the authorized service area, encompasses the entire Westlands, Broadview, Panoche, and Pacheco water districts, and the southern portion of the San Luis Water District (Figure ES-3). Reclamation also included the entire Grassland Drainage Area (some of which lies outside the Unit) in the drainage service area because the drainage systems are closely interrelated with the lands in the Unit and Section 5 of the San Luis Act authorizes participation of adjacent lands in San Luis Unit drainage facilities. The drainage-affected area (drainage service area) is estimated to be 379,000 acres. Reclamation estimates that 254,000 acres would have on-farm drains installed by 2050. This includes 236,000 acres in the Unit, and 18,000 acres in the Grassland Drainage Area outside the Unit.

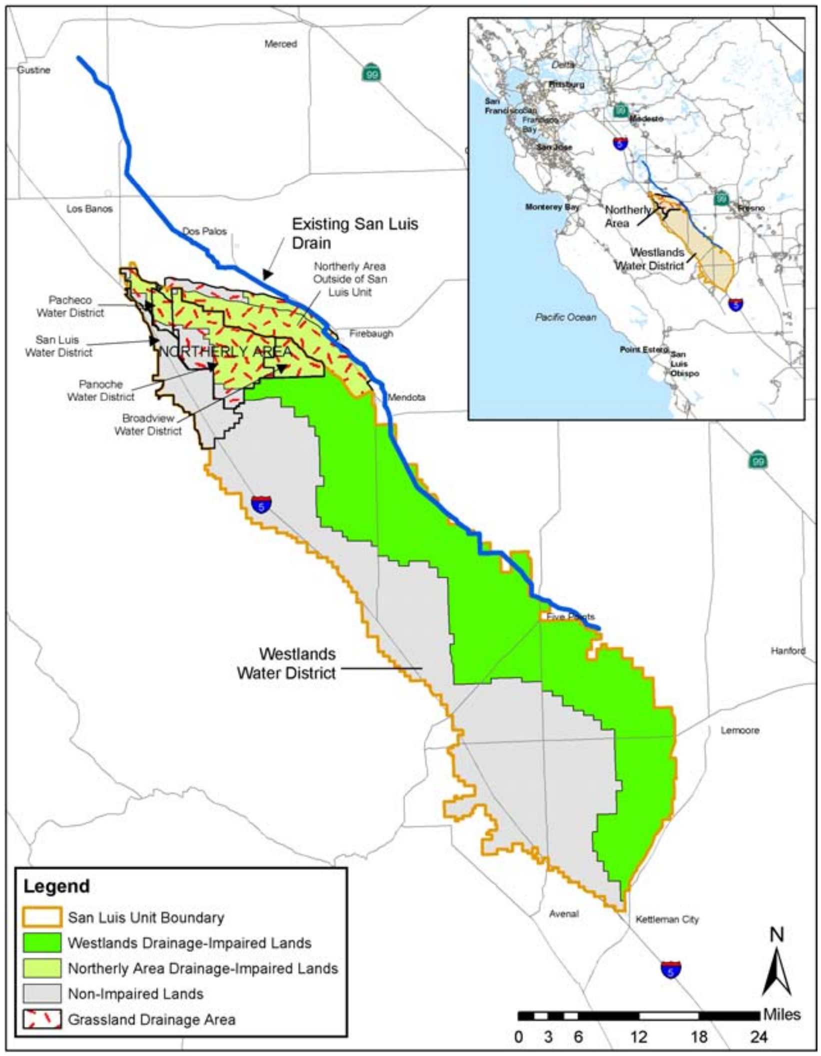


Figure ES-3 Drainage Study Area

The geographic scope of the analysis consists of the drainage study area (study area) and the areas affected by disposal alternative features such as conveyance, treatment facilities, and discharge locations, extending beyond the San Joaquin Valley to the Pacific Ocean at Point Estero and to the Sacramento-San Joaquin River Delta.

DRAINAGE QUANTITY AND QUALITY

For the purposes of the Re-evaluation, Reclamation has defined drainage service as removing water from irrigated fields to maintain long-term, sustainable salt and water balance in the root zone of irrigated lands. To design and construct the appropriate facilities required for removing the drainwater, Reclamation estimated the quantity and quality of the drainwater. Reclamation evaluated three factors affecting drainage quantity and quality:

- Which lands will ultimately need drainage to maintain arability of the soil
- The rate at which water will need to be drained off the fields to maintain arability of the soil
- What reasonable on-farm and in-district drainwater reduction actions could be implemented

Based on modeling of the groundwater conditions and agricultural productivity, Reclamation identified the lands that would require drainage service, the rate at which farmers would install tile drains to collect drainwater, and the rate that water would need to be drained from the fields to maintain arability.

Reclamation then evaluated the potential drainwater reduction actions that could be implemented on-farm, in-district, or as regional facilities. Reclamation determined that regional drainwater reuse facilities would be a cost-effective measure for reducing the volume of drainwater for treatment and disposal and should be included in all alternatives. Reuse facilities irrigate salt-tolerant crops with unblended drainwater.

To determine the quantity and quality of drainwater the collection and reuse systems would receive from farms and water districts (and therefore the size of the facilities), Reclamation identified additional drainwater reduction actions that would be more cost-effective than drainwater collection, reuse, treatment, and disposal. That is, Reclamation identified the drainwater reduction measures where the cost of reducing an acre-foot of drainwater would be less than the cost of collecting, reusing, treating, managing, and disposing that acre-foot of drainwater. To size the drainwater collection, reuse, treatment, and disposal facilities, Reclamation assumed that farmers and/or water districts would implement those actions that would be cost-effective. Farmers and water districts would have flexibility to select other measures to reduce drainwater.

Reclamation found three drainwater reduction measures to be cost-effective: drainwater recycling, shallow groundwater management, and seepage reduction. In addition, it was determined that the storage capacity of the groundwater aquifer beneath the reuse facilities could be used to regulate the seasonal variations in drainwater flows. Based on this analysis, Reclamation developed revised drainage quantities and flow rates, which were used in sizing facilities for all of the action alternatives. Table ES-1 shows the drainwater reduction and the resulting drainwater quantity. The difference in drainage output between the Out-of-Valley and In-Valley disposal options is related to the presence of evaporation ponds and associated mitigation facilities in the In-Valley Disposal option.

Table ES-1

Drainwater Reduction

Drainwater Volumes		
	Out-of-Valley Disposal (acre-feet per year)	In-Valley Disposal (acre-feet per year)
Drainage flow without reduction	141,700	138,900
Drainage flow with drainwater reduction activities (drainwater recycling, shallow groundwater management, and seepage reduction)	108,900	106,700
Drainage flow with drainwater reduction and regional reuse facilities	29,400	28,800
Average design flow with drainwater reduction and regional reuse facilities	41 cubic-feet/sec	40 cubic-feet/sec

ACTION ALTERNATIVES

Plan Formulation Process

Following publication of the Preliminary Alternatives Report in December 2001, Reclamation conducted additional analyses to develop final alternatives for evaluation and comparison. The development of alternatives focused on refining options within each of the three primary disposal concepts: In-Valley Disposal, Ocean Disposal, and Delta Disposal. The Reclamation team reviewed previous studies, conducted additional research on treatment and disposal options, developed preliminary cost and design information for facilities, and conducted field visits to potential conveyance corridors. At this time, detailed site-specific investigations have not been performed for the impact analyses.

Reclamation developed and applied screening criteria to the preliminary alternatives to assist in identifying the optimal alternative within a disposal concept. During alternative development and refinement, preliminary alternatives were only compared within a disposal concept and not compared against other disposal concepts.

Based on this evaluation, Reclamation identified four complete alternatives: one In-Valley Disposal Alternative, one Ocean Disposal Alternative (Point Estero), and two Delta Disposal Alternatives (Chipps Island and Carquinez Strait). The elements common to each alternative and the specific features of the alternatives are described below.

Common Elements to All Action Alternatives

Listed below are the project elements that are common to each of the action alternatives (Figure ES-4).

On-Farm, In-District Actions

As described above, Reclamation identified three drainwater reduction actions that would be cost-effective. Reclamation assumed implementation of these three actions for all alternatives, although these actions are not included in the Federal action to provide drainage service:

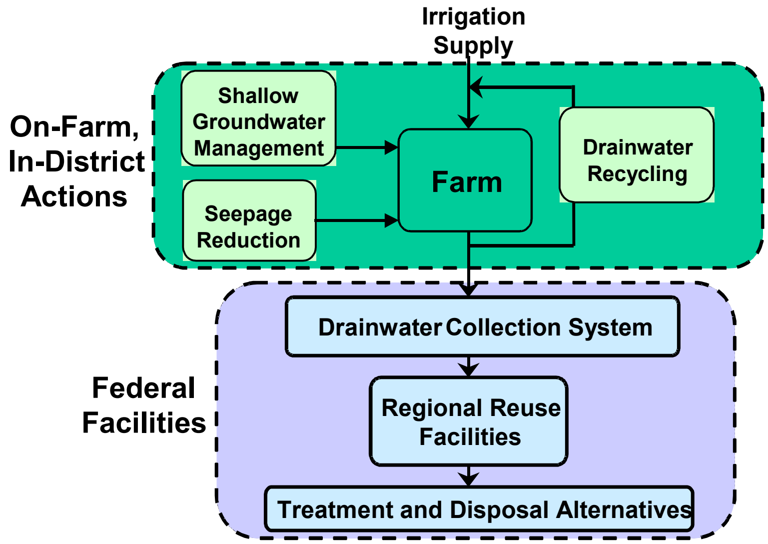


Figure ES-4 Common Elements

- **Drainwater Recycling –** Blending of drainwater, either at the farm or district level, with freshwater supplies up to a salinity level that is still acceptable for use on commercial crops.
- **Shallow Groundwater Management –** Managing groundwater levels in tile drain systems to partially utilize the shallow groundwater to meet crop needs.
- **Seepage Reduction –** Lining or piping of existing unlined irrigation conveyance and distribution facilities to reduce seepage loss into the groundwater.

Land Retirement

Land retirement can affect drainage service needs and, therefore, the size and configuration of drainage facilities. All action alternatives include the following land retirement actions which are in the process of being implemented:

- **Britz Settlement, September 3, 2002** (*Sumner Peck Ranch, Inc., et al. v. Bureau of Reclamation, et al.*) – 3,006 acres from Westlands are being retired permanently under a settlement agreement between the United States, Westlands, and the Britz group of plaintiffs in the Sumner Peck lawsuit.

- **CVPIA Land Retirement** – Up to 7,000 acres of lands are included to be retired within the study area under the existing Central Valley Project Improvement Act (CVPIA) land retirement program (2,091 acres retired to date).

Any future retirement of drainage affected lands pursuant to CVPIA, litigation settlement, or district programs that occur prior to implementation of any of the action alternatives could affect the size of the Federal drainage facilities.

Drainwater Collection

As part of the Federal action, Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse Facilities

As part of the Federal action, Reclamation would construct regional reuse facilities, which would use drainwater as an irrigation supply for salt tolerant crops. The reuse facility would also serve as an underground regulating reservoir to control the flow of reused drainwater to subsequent features.

Drainwater Treatment and Disposal

All action alternatives include disposal facilities, and three include drainwater treatment. The treatment technologies and disposal location vary with each alternative.

In-Valley Disposal Alternative

Summary Description

The In-Valley Disposal Alternative would lie within the San Joaquin Valley and entirely within the boundaries of the drainage study area (Figure ES-1). This alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be treated with reverse osmosis and biological selenium treatment before disposal in evaporation ponds (Figure ES-5).

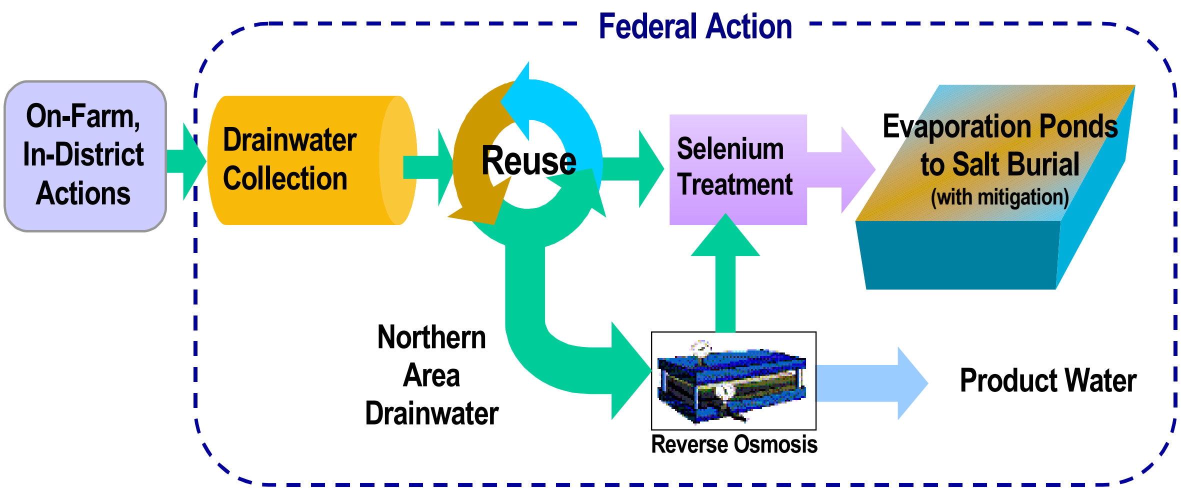


Figure ES-5 In-Valley Disposal Alternative

The key components of this alternative include the following:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection –Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to treatment facilities.

Reverse Osmosis – Reclamation determined that reverse osmosis treatment of the reuse drainwater is a cost-effective treatment technology in the Northerly Area. Reverse osmosis would remove salts and other contaminants from the drainwater, producing high quality water. This desalted product water would be blended with Central Valley Project water and used for commercial crop irrigation. The reverse osmosis treatment plant would also produce a concentrated waste stream requiring further selenium treatment and disposal. Reclamation determined that reverse osmosis would not be cost-effective for treating reuse drainwater from Westlands because of the higher hardness of the drainwater (higher concentrations of calcium and other minerals). Reverse osmosis would recover approximately 50 percent of the reuse drainwater in the Northerly Area for irrigation.

Selenium Biotreatment – Reused drainwater from Westlands and the concentrate from the reverse osmosis facility would be treated to remove selenium and reduce the environmental risk of evaporation pond disposal. Treatment would consist of the biological removal of selenium in aerated lagoons. To prevent seepage into local groundwater supplies each lagoon would consist of a concrete bottom with a secondary plastic liner. Floating covers on the lagoons would prevent oxygen interference with the process, reduce operating costs, and prevent wildlife access to the lagoon water. Selenium treatment produces a small amount of sludge (holding the concentrated selenium) that would be transported offsite for disposal as a hazardous material. Reclamation has estimated 80 percent selenium removal based on past studies.

Evaporation Ponds – Treated drainwater from the selenium treatment facilities would be collected and conveyed to two regional evaporation pond systems. These evaporation ponds would be constructed as needed through the planning period to a total planned acreage of approximately 5,000 acres. Salts precipitate and accumulate at the bottom of the ponds during evaporation and will require periodic excavation and burial of accumulated salts. Excavation and burial will not likely be required until after 80 to 100 years of operation. To maintain capacity, additional evaporation ponds would be constructed to replace ponds used for salt burial, if needed.

Mitigation Facilities – Mitigation habitat would likely be required to compensate for potential impacts to waterfowl and shorebirds exposed to elevated levels of selenium within the evaporation ponds. The quantity of land required for mitigation depends on the concentration of selenium within the ponds and other site-specific conditions, some of which would not be known until the ponds are operational and actual waterbird use can be monitored. Reclamation estimated that 3,200 to 6,400 acres of mitigation facilities would be required.

Key Elements

- 26,700 acres of regional reuse facilities
- Reverse osmosis treatment facility in the Northerly Area
- 160 acres of selenium treatment facilities
- 5,000 acres of evaporation ponds
- 3,200 to 6,400 acres of mitigation ponds
- Estimated total present worth cost of $946 million (2002 dollars), with an annual equivalent cost of $59.0 million

Ocean Disposal Alternative

Summary Description

The Ocean Disposal Alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be collected from the regional reuse facilities and transported by pipeline to the Pacific Ocean for disposal (Figure ES-6). The pipeline conveyance system would lie within the San Joaquin Valley from near Los Banos southeast to just south of Kettleman City, and then extend southwesterly to the Pacific Ocean at Point Estero (Figure ES-7). The ocean diffuser would be approximately 1.5 miles offshore, at a depth of 200 feet, approximately 10 miles south of the southern boundary of the Monterey Bay National Marine Sanctuary.

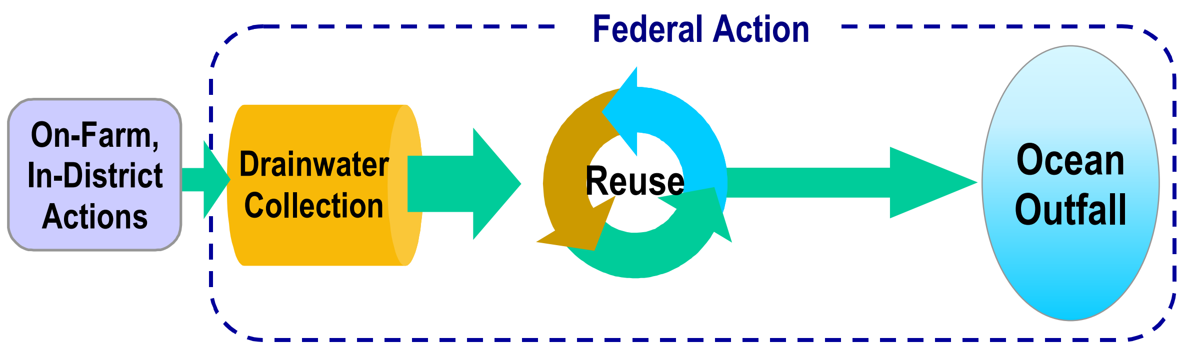


Figure ES-6 –Ocean Disposal Alternative

The key components of this alternative include the following:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to the ocean outfall for disposal.

Key Elements

- 27,200 acres of regional reuse facilities
- 177 miles of buried pipeline conveyance of drainwater using existing rights-of-way when possible, including three tunnels through the coastal range and ten pumping plants
- Estimated total present worth cost of $1,183 million (2002 dollars), with an annual equivalent cost of $73.7 million

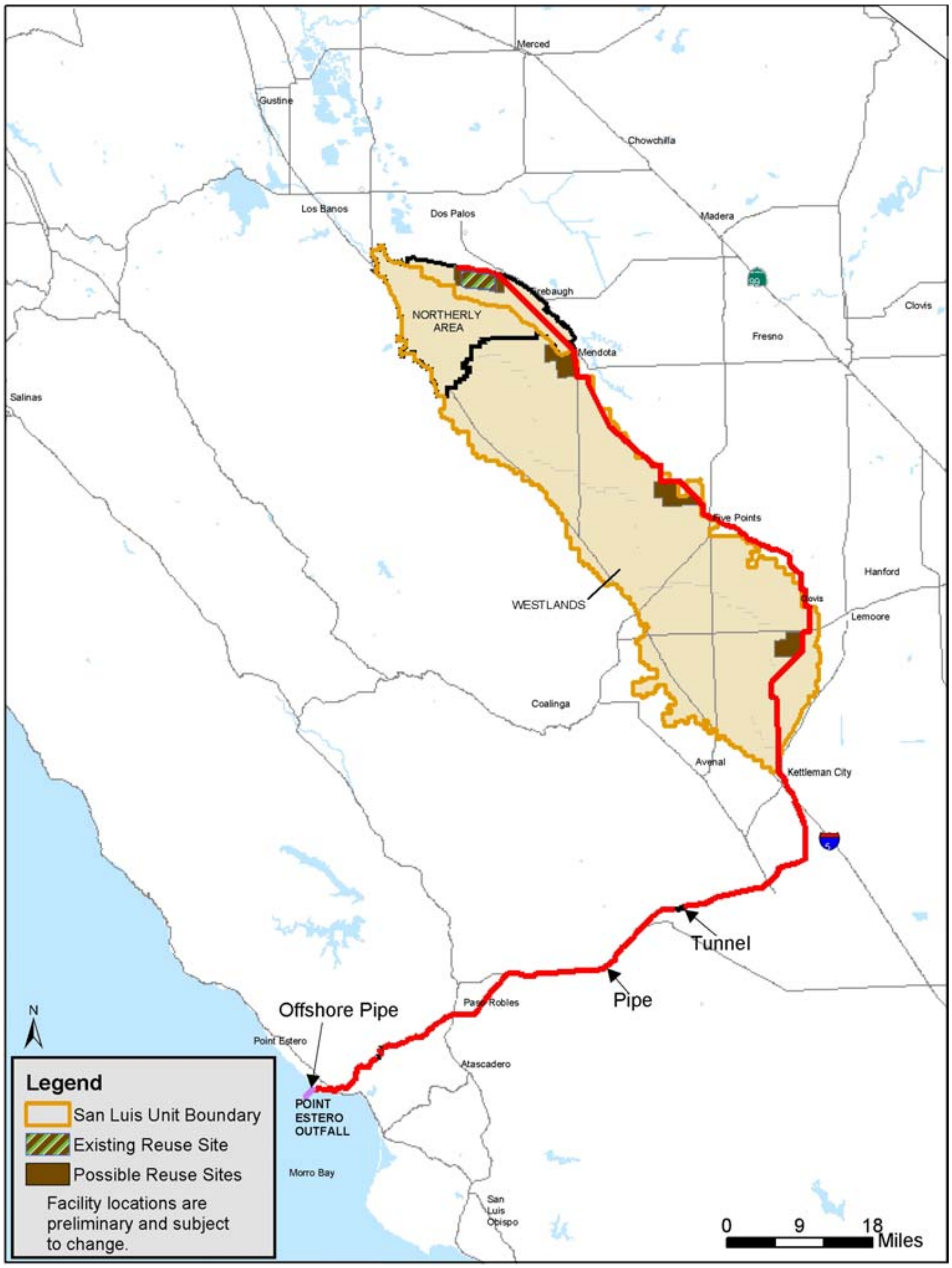


Figure ES-7 – Ocean Disposal Alternative

Delta-Chipps Island Disposal Alternative

Summary Description

The Delta-Chipps Island Disposal Alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be treated with biological selenium treatment before conveyance by canal and pipeline to the Sacramento-San Joaquin River Delta (Delta) for disposal (Figure ES-8). The canal and pipeline conveyance system would extend the existing San Luis Drain from its current terminous at Mud Slough to the north-northwest through Merced, Stanislaus, San Joaquin, Alameda, and Contra Costa counties for disposal at the west end of the Delta at Chipps Island (Figure ES-9). The Delta drainage aqueducts would traverse gradually sloping to flat lands on their way to the Delta. In two uphill areas, the flow would be in high-pressure pipelines from two pumping plants. The diffuser would be approximately 1 mile from the shoreline at Mallard Slough at a depth of 18 feet.

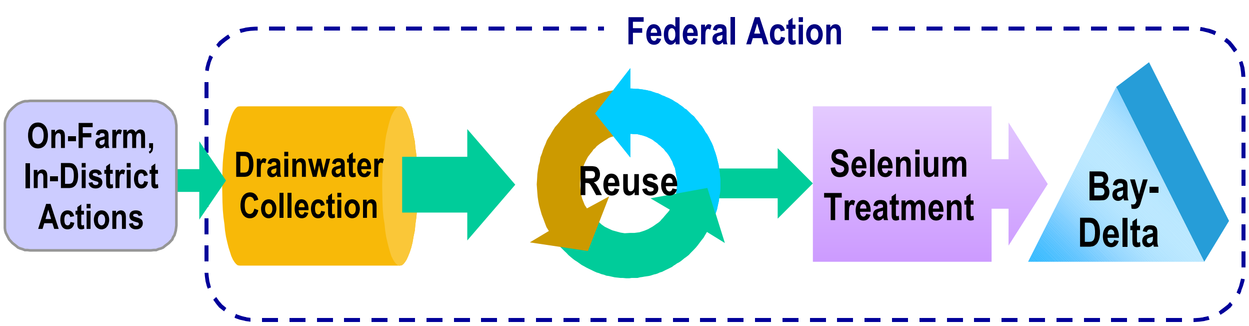


Figure ES-8 Delta-Chipps Island Disposal Alternative

The key components of this alternative include the following:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to treatment facilities.

Selenium Biotreatment –Drainwater from the regional reuse facilities would be treated to remove selenium and reduce the environmental impacts to the Delta. The treatment would be similar in size and approach to that described for the In-Valley Alternative.

Key Elements

- 27,200 acres of regional reuse facilities
- 160 acres of selenium treatment facilities
- Utilizes existing San Luis Drain
- 191 miles of pipeline and canal conveyance using existing rights-of-way (108 miles of new construction and 83 miles of the existing San Luis Drain)
- Canals and low-head pipelines in agricultural and sparsely populated areas
- Pipelines in urban and rapid growth areas
- Estimated total present worth cost of $1,006 million (2002 dollars), with an annual equivalent cost of $62.7 million

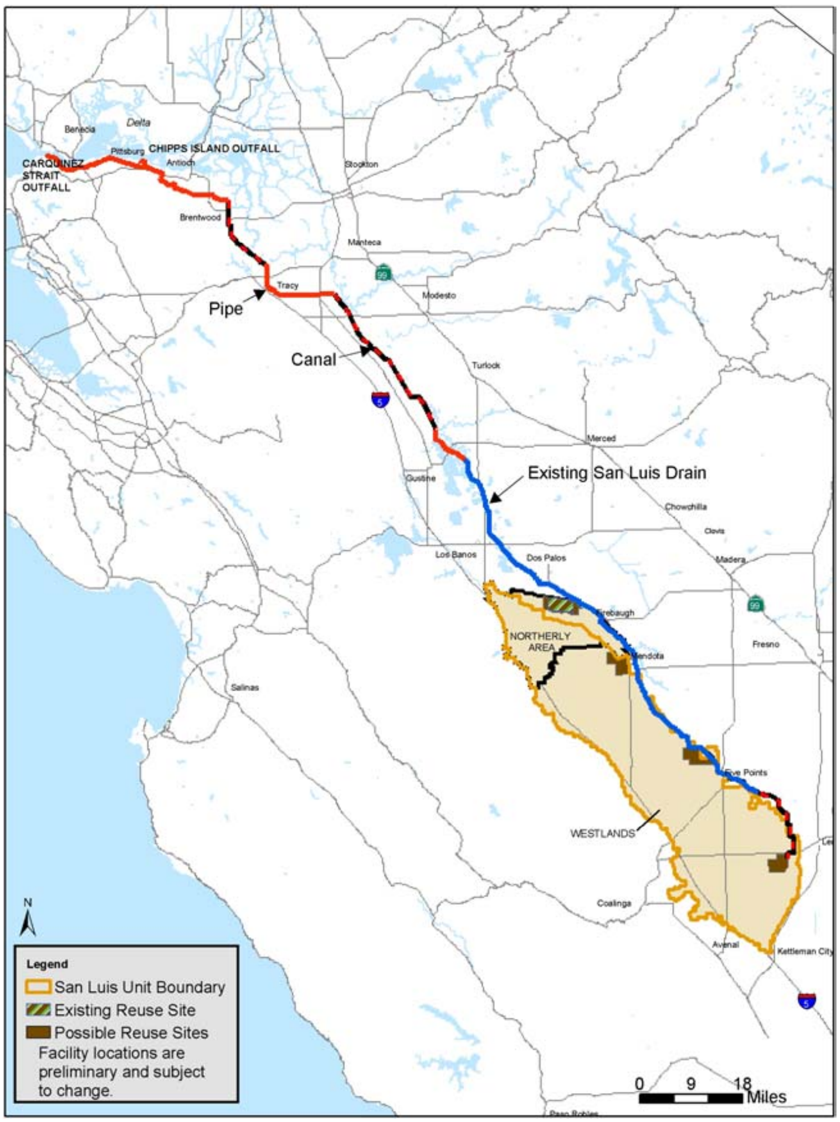


Figure ES-9 Delta Disposal Alternatives

Delta-Carquinez Strait Disposal Alternative

Summary Description

This alternative has the same route and design elements as the Delta-Chipps Island Disposal Alternative, except that it continues past Los Medanos to Carquinez Strait for disposal immediately upstream of Carquinez Bridge near the town of Crockett (Figure ES-9). The diffuser would be approximately 16 miles downstream of the western end of the Delta and 1 mile from the shoreline at Crockett at a depth of 18 feet. This disposal location has greater tidal action and is further removed from drinking water intakes than the Delta-Chipps Island Alternative.

On Farm, In District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct and operate a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to treatment facilities.

Selenium Biotreatment –Drainwater from the regional reuse facilities would be treated to remove selenium and reduce the environmental impacts to the Delta. The treatment would be similar in size and approach to that described for the In-Valley Alternative.

Key Elements

- 27,200 acres of regional reuse facilities
- 160 acres of selenium treatment facilities
- Utilizes existing San Luis Drain
- 208 miles of pipeline and canal conveyance using existing rights-of-way (125 miles of new construction and 83 miles of the existing San Luis Drain)
- Canals and low-head pipelines in agricultural and sparsely populated areas
- Pipelines in urban and rapid growth areas
- Estimated total present worth cost of $1,079 million (2002 dollars), with an annual equivalent cost of $67.2 million

NO ACTION ALTERNATIVE

The No Action Alternative is required under the National Environmental Policy Act (NEPA) and is formulated to provide a comparative baseline for evaluation of drainage service alternatives in the upcoming EIS. The No Action Alternative defines conditions in the project area through the planning time frame (2001 through 2050) if drainage service is not provided to the Unit and related areas. It represents existing conditions for drainage management in 2001 with limited changes in management reasonably expected to occur by individual farmers and districts in the absence of Federal drainage service. The No Action Alternative includes only regional conveyance, treatment, or disposal facilities that existed in 2001 or that are authorized, funded projects.

Without Federal drainage service, farmers and districts would not be able to discharge drainwater to receiving waters (sloughs, rivers, bays, or ocean) from drainage-impaired lands, except where such discharges are currently permitted (e.g., the Grassland Bypass Project). Without drainage service, farmers would pursue individual actions related to drainage control and reuse and cropping patterns. Water districts and landowners would continue to address drainage problems within institutional, regulatory, and financial constraints currently in effect and reasonably foreseeable.

Land Retirement

Reclamation reviewed existing approved land retirement programs to identify drainage-impaired lands that could reasonably be expected to be retired within the study area.

- **Britz Settlement, September 3, 2002 (*Sumner Peck Ranch, Inc., et al. v. Bureau of Reclamation, et al.*)** – 3,006 acres from Westlands are being retired permanently under a settlement agreement between the United States, Westlands, and the Britz group of plaintiffs in the Sumner Peck lawsuit. These retired lands are assumed for all alternatives.

- **CVPIA Land Retirement** – Up to 7,000 acres of lands are included to be retired within the study area under the existing CVPIA land retirement program (2,091 acres retired to date). These retired lands are assumed for all alternatives.

- **Westlands Settlement Agreement (*Sagouspe v. Westlands Water District*)** – A settlement agreement among various classes of water users within Westlands calls for temporary retirement of land. An estimated 68,400 acres of land would be retired under this settlement agreement. Because the agreement would allow these lands to come back into production if and when Reclamation provides drainage service, Reclamation assumed these lands would be retired only under the No Action Alternative.

Key Elements

- Part of the Grassland Drainage Area's planned In-Valley Treatment/Drainage Reuse Facility would be included in the No Action Alternative. The constructed and funded components include 4,000 acres of land for planting with salt-tolerant crops
- Land retirement of 78,406 acres
- The San Luis Drain would not be used to convey drainage except for the northern area of the Unit as part of the Grassland Drainage Area
- No additional irrigated acres would be brought on line
- No new managed wildlife areas developed within the study area
- No changes to land fallowing patterns

SUMMARY OF ALTERNATIVES COMPARISON

Reclamation conducted a preliminary impact analysis of each of the four action alternatives to evaluate and compare the alternatives. Reclamation conducted an appraisal level analysis of 12 topics for each alternative (see sidebar). The results of the preliminary impact analysis are described in Section 6 of the report. Based on the results of the preliminary impact analysis, Reclamation evaluated and compared the alternatives in five major categories to identify the proposed action. These categories were cost, time to implement, implementation complexity (including flexibility to adapt to changing conditions and permitting complexity), environmental effects and risks (including land and water resources impacts and public health), and public concern. The following is a brief discussion of Reclamation's evaluation. Section 7 of this report describes evaluation of these alternatives. Table ES-2 shows a summary comparison of the alternatives.

Preliminary Impact Analysis Topics

The Plan Formulation Report includes an initial analysis of impacts in the following areas. A complete impact analysis will be provided in the EIS scheduled for completion in 2004.

- *Cost*
- *Time to Implement*
- *Water quality and quantity*
- *Biological resources*
- *Geology*
- *Energy resources*
- *Air quality*
- *Agricultural economics*
- *Land use*
- *Aesthetics*
- *Social issues and environmental justice*
- *Public concern*

Table ES-2
Comparison of Alternatives

Evaluation Factors	Alternatives			
	In-Valley Disposal	Delta Disposal (Chipps Island)	Delta Disposal (Carquinez Strait)	Ocean Disposal
Cost (Total Present Worth, $ millions)	946	1,006	1,079	1,183
Time to Implement	Green	Yellow	Yellow	Red
Implementation Complexity	Green	Red	Red	Yellow
Permitting Complexity	Green	Red	Red	Yellow
Flexibility	Green	Red	Red	Yellow
Environmental Effects & Risks	Yellow	Red	Red	Yellow
Land Impacts	Green	Red	Red	Yellow
Drinking Water	Green	Red	Yellow	Yellow
Salts Disposal	Yellow	Yellow	Yellow	Green
Selenium Exposure	Red	Red	Red	Green
Hazards	Green	Yellow	Yellow	Yellow
Public Concern	Green	Red	Red	Yellow

Green	Least impact or difficulty
Yellow	Moderate impacts or difficulty
Red	Greatest impact or difficulty

In-Valley Alternative. The In-Valley Alternative has the lowest cost (see Table ES-3). The alternative has the shortest time to implement because it would allow for phased construction of evaporation ponds as farmers install tile drains on their lands. This alternative also has the least complex implementation (the least complex permitting process and the most flexibility to adapt to changing conditions). For environmental issues, the In-Valley Alternative would have fewer impacts to land-based natural resources than the other alternatives. While Reclamation recognizes the potential environmental impacts associated with large areas of evaporation ponds, the inclusion of selenium treatment and appropriate wetlands mitigation is expected to mitigate these impacts. While this alternative is likely to generate public concern about evaporation ponds and potential effects on wildlife, the level of concern is expected to be less than for the other alternatives because the drainwater would be managed in the area where it is produced.

Table ES-3
Summary of Project Costs ($ millions, 2002 dollars)

	FEDERAL COST			TOTAL COST	
Alternatives	Construction	Annual O&M	Present Worth	Annual Equivalent	Present Worth
IN-VALLEY	716	16.3	779	59.0	946
DELTA—CHIPPS	763	14.6	836	62.7	1,006
DELTA—CARQUINEZ	833	14.6	909	67.2	1,079
OCEAN	920	17.5	1,013	73.7	1,183

Federal Cost – Costs for facilities that would be part of the Federal drainage service plan and are Federally funded. See Figure ES-4 for the components that would be Federal facilities.

Total Cost – The Federal Cost plus the cost for all on-farm/in-district drainwater reduction measures.

Construction – All capital costs for lands, rights-of-way, construction, mitigation, and interest during construction.

Annual O&M – All costs required each year to operate, maintain, and replace project facilities, including energy costs.

Present Worth – The combined construction and annual operations and maintenance costs presented as a one-time cost.

Annual Equivalent – The present worth cost presented as a series of equal annual payments over 50 years.

The Federal costs for each of the action alternatives would exceed the current Federal spending limit authorized under the San Luis Act

Ocean Disposal Alternative. The Ocean Disposal Alternative is the most costly of the four alternatives and would have the longest time to implement. This alternative is the second ranked alternative for implementation complexity; it would have flexibility to adapt to changes in drainage quality, but less flexibility to adapt to changes in drainage quantity. This alternative would have greater impacts to land-based natural resources than the In-Valley alternative, but slightly fewer risks for other resources (salts would be removed from the valley water cycle and less risk of wildlife exposure to selenium). The Ocean Disposal Alternative is expected to cause public concern about impacts to ocean and coastal resources, including marine sanctuaries.

Delta Disposal Alternatives. The Delta Disposal Alternatives are the second most costly alternatives and have the second shortest time to implement. These alternatives were the most complex to implement (little flexibility to adapt to changing conditions and the most complex permitting process). These alternatives would have the largest potential for impacts to land-based resources, aquatic resources, and drinking water. As a result of these potential impacts, this alternative is expected to cause greater public concerns than the other alternatives.

Based on this evaluation, Reclamation identified the In-Valley Alternative as the proposed action. The proposed action, along with the other action alternatives and the No Action Alternative, will be carried forward into the next phase of the Re-evaluation for further development and detailed environmental review, consistent with the National Environmental Policy Act.

LAND RETIREMENT SCENARIOS

Due to interest in land retirement scenarios, Reclamation evaluated three possible levels of land retirement to determine how they might affect the facilities and costs for providing drainage service. Reclamation did not evaluate these land retirement scenarios as alternatives for providing drainage service because taking land out of production would not meet the project purpose as defined by court order to provide drainage service to the Unit. Reclamation identified the reduced quantity of drainwater that would result from three levels of land retirement and the resulting cost reductions for drainage service facilities:

- **Rainbow Report** – The 1990 Rainbow Report (San Joaquin Valley Drainage Program 1990) and the 1991 San Luis Unit Drainage Report identified approximately 34,000 – 48,000 acres for retirement within Westlands. Consequently, Reclamation evaluated the retirement of 40,000 acres.
- **Westlands Proposal** – Westlands has proposed a plan to retire 200,000 acres of land within the district.
- **No Drainage Service for Westlands** – One possible aspect of Westlands' land retirement proposal is that Westlands would relieve Reclamation of its obligation to provide drainage service to the district. Under this scenario, Reclamation assumed that drainage service would be provided for 81,000 acres in the Northerly Area.

For these three scenarios, Reclamation identified the remaining quality and quantity of subsurface drainwater still requiring disposal from the Unit and recalculated the cost for the Federal portion of the drainage solution, including collection, conveyance, reuse, treatment, and disposal. Costs for land acquisition, management of retired lands, or on-farm and in-district drainwater reduction activities are not included. The comparative costs are shown in Table ES-4. For example, Table ES-4 shows that retiring 40,000 acres would reduce the Federal cost for the In-Valley Disposal alternative by $40 million.

Table ES-4
Drainage Cost Comparison with Land Retirement

Present Worth for Federal Action ($ millions)				
	In-Valley Disposal	Delta Disposal (Chipps Island)	Delta Disposal (Carquinex Strait)	Ocean Disposal
No Additional Land Retirement	779	836	909	1,013
40,000 Acre Reduction	739	780	834	1,004
Difference from Original	(40)	(56)	(75)	(9)
200,000 Acre Reduction	603	639	666	749
Difference from Original	(176)	(197)	(243)	(264)
No Service for Westlands Water District	186	236	261	277
Difference from Original	(593)	(600)	(648)	(736)

– Does not include cost of land acquisition or management of retired lands.
– Does not include cost of on-farm/in-district drainwater reduction actions.

PUBLIC AND AGENCY INVOLVEMENT

From the outset of the Re-evaluation process, Reclamation has sought the participation of agencies and stakeholders in the development of drainage service options and the evaluation of alternatives. Given the project's complex history, continuing outreach was required to maintain communication and collaboration among all the critical stakeholders. Stakeholders, including the agricultural community, urban and environmental groups, coastal interests, agencies, and elected officials, have continued to provide substantive input into the alternatives evaluation (Figure ES-10).

Following the publication of the Notice of Intent to prepare an EIS, Reclamation conducted an agency scoping meeting followed by two public scoping meetings in Fall 2001. Comments received were summarized in the Preliminary Alternatives Report released in December 2001.

To date, Reclamation has held four workshops, eight focused outreach briefings, and three public meetings to share information on project developments and to receive input. Stakeholder input has been significant, including more than 40 written comments. These comments were carefully considered and, in many cases, integrated into the project approach and analysis. In evaluating the alternatives, Reclamation used public input to assess potential concerns.

Project documents and background educational material (including a project newsletter, briefing packets, factsheets, and meeting presentations) are available to the public at meetings, via mail, and on the project web site.

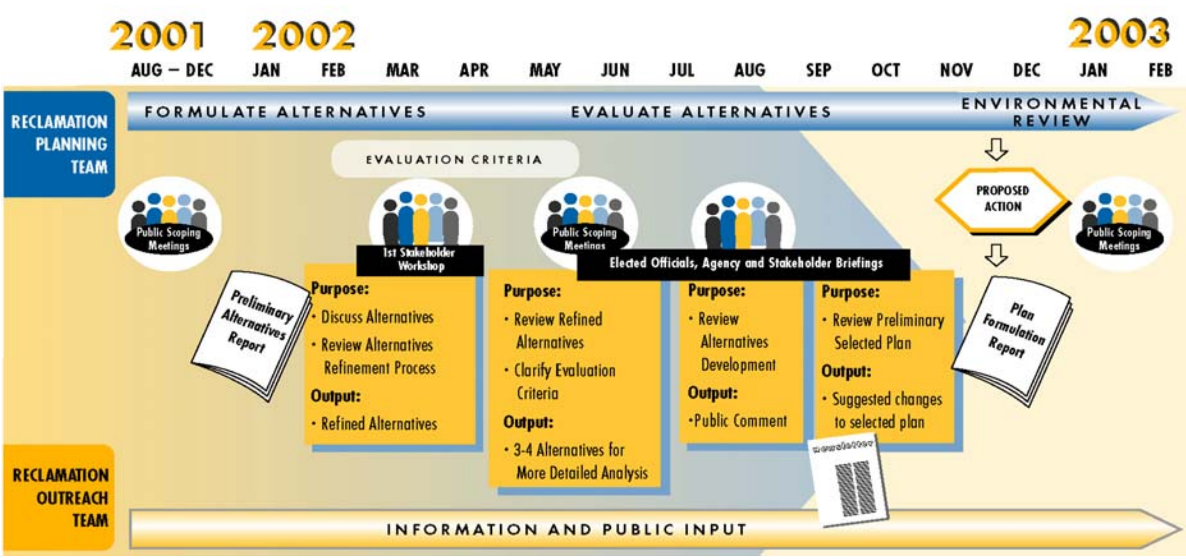


Figure ES-10 Public Outreach Process

In 2003, as part of the environmental documentation process, Reclamation will convene a cooperating agency group. An additional round of public scoping meetings will be conducted in the geographic areas potentially affected by the final alternatives. Small group briefings will continue their important role in exchanging information regarding the environmental impact analysis and other project activities.

ORGANIZATION OF PLAN FORMULATION REPORT

The complete Plan Formulation Report contains additional detail on the project background and purpose, drainage quantity and quality, alternatives development and evaluation, and selection of the proposed action. The report is organized in nine sections with supporting technical appendices as follows:

- Section 1: Introduction
- Section 2: Study Area
- Section 3: Drainage Quantity and Quality and Drainwater Reduction
- Section 4: Plan Formulation and Evaluation Process
- Section 5: Description of Alternatives
- Section 6: Preliminary Impact Analysis
- Section 7: Selection of Proposed Action
- Section 8: References
- Section 9: Report Preparation

SECTIONONE

INTRODUCTION

This Introduction to the Plan Formulation Report identifies the purpose and authority for the San Luis Drainage Feature Re-evaluation, the organization of the Report, and the historical context for the current evaluation of alternative solutions for providing drainage service to the San Luis Unit.

1.1 PURPOSE AND AUTHORITY FOR RE-EVALUATION

In response to a court order, the Bureau of Reclamation (Reclamation) is re-evaluating options for providing drainage service to the San Luis Unit (the Unit) (see Figure 1.1-1). The San Luis Drainage Feature Re-evaluation (the Re-evaluation) will allow Reclamation to formulate and implement a plan that provides agricultural drainage service to the Unit that achieves long-term, sustainable salt and water balance in the root zone of irrigated lands. The Re-evaluation is being conducted pursuant to Public Law 86-488, which authorized the Unit.

The history of Reclamation's attempts to provide drainage service to the Unit is punctuated by a series of litigations, the most recent of which (*Sumner Peck Ranch, Inc. et al. v. Bureau of Reclamation et al.*[U.S. District Court for the Eastern District of California 2002]) compels Reclamation to provide drainage service to the Unit promptly. In response to the court's order, Reclamation developed a Plan of Action (Reclamation 2001c), which outlines Reclamation's proposed efforts to provide prompt drainage service, including consideration of a variety of options.

The first phase of the Re-evaluation, consistent with the Plan of Action, was the process of identifying a list of preliminary alternatives that meet the court's order to provide prompt drainage service to the Unit. The result of first phase was *Preliminary Alternatives Report (PAR), San Luis Unit Drainage Feature Re-evaluation*, which was published in December 2001 (Reclamation 2001a). The alternatives described in the PAR meet the court order and use proven technology.

This Plan Formulation Report (the Report) is the product of the second phase of the Re-evaluation effort, which included the determination of the lands that require drainage service; the anticipated quantity and quality of drainwater for which Reclamation will need to provide service; the formulation, evaluation, and screening of the preliminary alternatives; the description of the final set of alternative plans; and the selection of the proposed action.

PURPOSE OF THIS REPORT

This Plan Formulation Report sets forth the analysis of alternatives for providing drainage service to the San Luis Unit. The Report describes the process of:

- *Refining and evaluating alternatives*
- *Selecting four final alternatives*
- *Conducting a preliminary impact analysis*
- *Comparing alternatives*
- *Identifying the proposed action*

This Report accomplishes the important objective of meeting the Plan of Action milestone for identifying a proposed action by December 2002.

During the next phase of the Feature Re-evaluation process, Reclamation will refine the components of the proposed action, provide additional engineering detail, and complete the environmental review of the proposed action and alternatives.

1.2 PLAN FORMULATION REPORT

The primary purpose for this Report is to describe the final set of alternatives being evaluated by Reclamation to provide drainage service to the Unit and to present the selection process for the proposed action.

This Report is organized as follows:

- Section 1 (this section) describes the history of Unit issues.
- Section 2 evaluates the areas needing drainage service.
- Section 3 identifies and evaluates the cost-effectiveness of several drainwater reduction measures and estimates the anticipated drainage quantity and quality.
- Section 4 provides documentation on the evaluation of disposal alternatives and drainage quantity and quality over the period January through August 2002.
- Section 5 describes the No Action Alternative and the four action alternatives resulting from the initial screening process.
- Section 6 is a summary of the preliminary analysis of the potential adverse and beneficial impacts of the alternatives.
- Section 7 describes the process used to screen the four action alternatives for a proposed action and describes the next steps.
- Section 8 contains the list of references used to prepare this Report.
- Section 9 contains the list of Report preparers.

The information in this Report provides the basis for more detailed impact analyses of the proposed action and other reasonable alternatives.

1.3 HISTORICAL PERSPECTIVE

Planning for drainage facilities to serve the San Joaquin Valley has occurred since the mid-1950s. Drainage facilities were discussed when Reclamation studied the feasibility of water supply development for the Unit. In the 1957 California Water Plan, the California Department of Water Resources (DWR) also planned for drainage facilities from near the Buena Vista lakebed in Tulare Basin to the Sacramento-San Joaquin River Delta (the Delta). Figure 1.3-1 provides an overview of historical and future events for San Joaquin Valley drainage planning.

In 1960, Congress enacted Public Law 86-488 authorizing construction of the San Luis Unit of the Central Valley Project (CVP). Also in 1960, California voters approved the Burns-Porter Act authorizing the State Water Project to build facilities to remove drainwater from San Joaquin Valley.

In the early 1960s, the plan for the construction of the San Luis Interceptor Drain (the Drain) changed from an unlined ditch to a concrete-lined canal. Later, a flow-regulatory reservoir (Kesterson Reservoir) was added. In 1968, Reclamation began construction of the Drain and the first stage of Kesterson Reservoir. By 1975, an 82-mile segment of the Drain (ending at Kesterson Reservoir) was completed, and subsequently 120 miles of collector drains were

Figure 1.1-1 Regional Location Map

constructed in a 42,000-acre area of the northeast portion of Westlands Water District (Westlands).

Between 1975 and 1979, the San Joaquin Valley Interagency Drainage Program, a joint effort between Reclamation, the DWR, and the State Water Resources Control Board (State Board), was formed to find an economically, environmentally, and politically acceptable solution to San Joaquin Valley drainage problems. This group recommended that a drain be completed to the Delta, terminating near Chipps Island. The State again declined to participate in a master drain and, based on the San Joaquin Valley Interagency Drainage Program's recommendation, Reclamation initiated a special study to fulfill the requirements for a discharge permit from the State Board for a Federal-only drain.

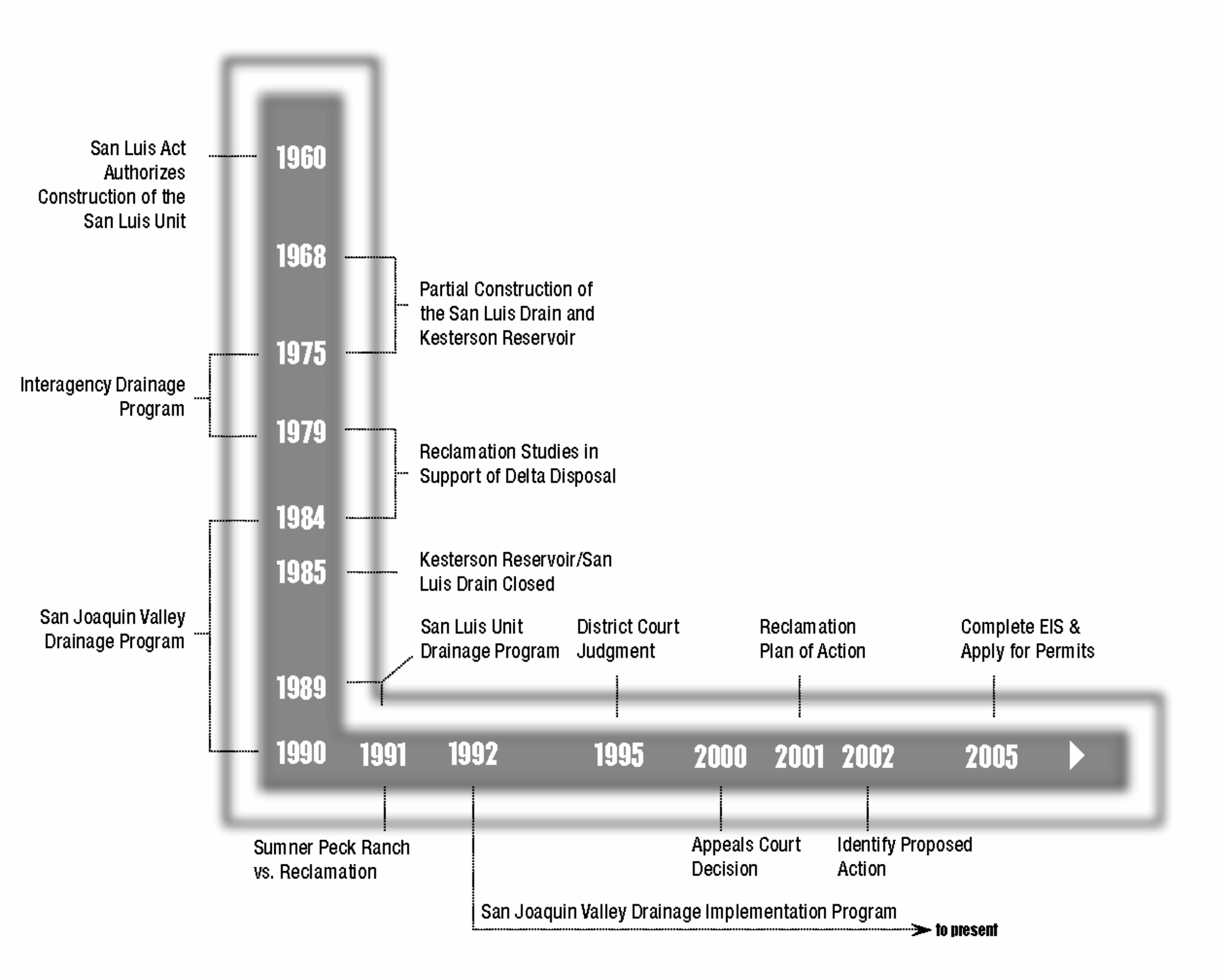


Figure 1.3-1 San Luis Unit Drainage Timeline

In 1983, discovery of embryonic deformities of aquatic birds at Kesterson Reservoir significantly changed the approach to drainage solutions in San Joaquin Valley. Because of the high selenium (Se) levels found in the drainwater and its effects at Kesterson Reservoir, the San Luis Unit Special Study was suspended. In 1985, following a Nuisance and Abatement Order issued by the State Board, discharges to Kesterson Reservoir were halted, and feeder drains leading to the Drain were plugged.

In response to the Kesterson problems, the San Joaquin Valley Drainage Program (SJVDP) was formed by the governor of California and the secretary of the U.S. Department of the Interior (Interior). This joint Federal/State effort was established to develop solutions to drainage and drainage-related problems. While the initial efforts looked at all possible solutions, a policy decision in 1987 limited studies to in-valley drainage management measures based on a recommendation from a citizens advisory committee consisting of water users, environmental advocates, and public interests. The SJVDP's final report (SJVDP 1990) recommended an in-valley solution that included source reduction, drainage reuse, land retirement, evaporation ponds, groundwater management, San Joaquin River discharge, and institutional changes. This plan provided a strategy for managing salts through 2040 and stated that eventually salts may need to be removed from San Joaquin Valley.

While the SJVDP was preparing its recommendations, a 1986 Federal court order settled a lawsuit among Westlands, Reclamation, and various classes of landowners and water users in Westlands. Named after one of the parties to the lawsuit, the Barcellos Judgment addressed, among other things, the supply of water to Westlands and the provision of drainage service to Westlands. It directed Reclamation to develop, adopt, and submit to Westlands a plan for drainage service facilities by the end of 1991, leading to preparation of the San Luis Unit Drainage Program plan formulation document and the related draft environmental impact statement.

Several landowners subsequently sued Interior, seeking completion of the master drain to the Delta. These lawsuits were partially consolidated in 1992 to address the common allegation that Interior was required by law to construct drainage service facilities from certain lands in the Unit. In 1995, the district court issued a partial judgment stating that the San Luis Act established a mandatory duty to provide drainage. The judgment ordered Interior to promptly prepare, file, and pursue an application for a discharge permit with the State Board. Interior appealed this judgment.

In February 2000, the U.S. Court of Appeals concluded that Interior must provide drainage service but held that Interior had the discretion to meet the court order with a plan other than the interceptor drain solution.

SECTION TWO

STUDY AREA

The geographic scope of the analysis consists of the drainage study area (study area) and other areas affected by disposal alternative features such as conveyance, treatment facilities, and discharge locations. The geographic scope extends beyond the San Joaquin Valley west to the Pacific Ocean at Point Estero and northwest to the Sacramento-San Joaquin River Delta.

The study area is located in the western San Joaquin Valley and consists primarily of the lands lying within the boundary of the San Luis Unit of the Central Valley Project (CVP).

The Unit, as defined by the authorized service area, encompasses the entire Westlands, Broadview, Panoche, and Pacheco Water Districts and the southern portion of the San Luis Water District (Figure 1.1-1).

In addition, Reclamation decided to incorporate areas outside the Unit but part of the Grassland Drainage Area (GDA) into the study area for this Re-evaluation.

The entire study area (including the lands to the north and outside of the Unit) totals approximately 730,000 acres.

Of these 730,000 acres, approximately 379,000 acres would be drainage-impaired and constitute the drainage service area for 2050, the planning horizon for the Re-evaluation.

It is reasonable to expect that not all of this service area would actually be drained in 2050. Some farmers could elect not to install subsurface drains based on localized conditions or economic considerations. For the Re-evaluation, Reclamation estimates that two-thirds of the drainage service area would actually have subsurface drainage systems installed by 2050 (254,000 acres). **Consequently, Reclamation used 254,000 acres to estimate the drainwater quantity.**

Sections 2.1 through 2.3 provide a more detailed analysis of the lands identified above.

2.1 LANDS IN THE STUDY AREA

The geographic scope of analysis consists of the study area and the areas affected by disposal features such as conveyance, treatment facilities, and discharge locations. Therefore, the geographic scope extends to the Pacific Ocean at Point Estero and into the Delta at Chipps Island and Carquinez Strait (Figure 1.1-1).

Section 5 of the San Luis Act authorizes the inclusion of lands in the general area of the Unit in the drainage service facilities. Three areas adjacent to the Unit were considered for inclusion in this Report: lands adjacent to the northern San Luis Unit water districts, lands to the east and south of Westlands, and lands immediately to the east of Westlands. These areas are described below.

STUDY AREA

The study area is located in the western San Joaquin Valley and consists primarily of the lands lying within the boundary of the CVP's San Luis Unit. The Unit, as defined by the authorized service area, encompasses the entire Westlands, Broadview, Panoche, and Pacheco Water Districts and the southern portion of the San Luis Water District (Figure 1.1-1).

In addition, Reclamation decided to incorporate areas outside the Unit but part of the Grassland Drainage Area (GDA) into the study area for this Re-evaluation.

The northern San Luis Unit districts (the Broadview, Panoche, and Pacheco Water Districts and the Charleston Drainage District within the San Luis Water District) and some adjacent lands are part of the GDA. The GDA was created in the mid-1990s as a regional drainage entity under the umbrella of the San Luis and Delta-Mendota Water Authority. The GDA was created to address drainage issues, particularly the discharge of subsurface drainwaters containing high Se levels to wetland areas and ultimately to the San Joaquin River.

Reclamation decided to incorporate the entire GDA in the study area in this plan formulation analysis, including the lands both inside and outside the Unit. The lands outside the Unit included in the GDA are the Exchange Contractor lands in Firebaugh Canal Water District, lands within the Central California Irrigation District (Camp 13 Drainage District), lands outside of the Panoche Water District but within the Panoche Drainage District, Widren Water District, and some unincorporated areas.

The other two areas outside of the San Luis Unit were not included in the analysis in this Report. The lands in Kings and Kern Counties to the south and east of Westlands were not included because they either already provide drainage service or may be too far from the Unit to make service practical. Contact was made with districts immediately to the east of Westlands. These districts indicated the depth to water in their areas was such that they would likely not be interested in having Reclamation provide drainage service (Sarge Greene, Manager, Tranquility Irrigation District, pers. comm., April 2002).

For this Report, the study area has been subdivided into the Westlands Water District and the Northerly Area. Similar to the approach taken in the PAR (Reclamation 2001a), the lands within Westlands have been broken down into three subareas (north, central, and south). These subareas have significantly different quality characteristics that may allow for better planning for treatment and/or disposal of drainwater. The Northerly Area includes all of the GDA and the southern portion of the San Luis Water District. The entire study area totals approximately 730,000 acres. A tabulation of the area included within the study area is shown in Table 2.1-1, and a map of the study area is shown on Figure 2.1-1.

Table 2.1-1
Drainage Study Area

District	Area (acres)
Westlands Water District	604,000
Northern San Luis Unit Districts	85,600
Northerly Area Outside of San Luis Unit	40,400
Subtotal (Northerly Area)	126,000
Total	**730,000**

Note: All areas as acreage reported by the water districts except the San Luis Water District, which was calculated using Arc GIS.

Figure 2.1-1 Drainage Study Area

2.2 AREAS NEEDING DRAINAGE BY 2050

Table 2.2-1 summarizes the areas needing drainage service by 2050 for both the Northerly Area and Westlands, resulting in a drainage service area of 379,000 acres for the entire study area. How these estimates were derived is explained below.

Table 2.2-1
Area Needing Drainage Service by 2050

District	Area (acres)
Westlands North	102,000
Westlands Central	104,000
Westlands South	92,000
Subtotal (Westlands Water District)	298,000
Northern San Luis Unit Districts	45,000
Northerly Area Outside of San Luis Unit	36,000
Subtotal (Northerly Area)	81,000
Total	**379,000**

The areas needing drainage service by 2050 were evaluated from previous projections and information collected as part of this Report. These previous projections for Westlands are shown in Table 2.2-2.

Table 2.2-2
Past Projections of Area Needing Drainage Service in the Westlands Water District

Projection	Area (acres)
Johnston (1993)	
Westlands North	64,000
Westlands Central	79,000
Westlands South	48,000
Total	**191,000**
Busch (1994)	
Westlands North	102,000
Westlands Central	104,000
Westlands South	92,000
Total	**298,000**
PAR (2001a)	
Westlands North	75,000
Westlands Central	75,000
Westlands South	75,000
Subtotal (Westlands Water District)	225,000
San Luis Unit Districts	35,600
Total	**260,600**

The Johnston (1993) numbers in Table 2.2-2 were developed based on the area of land with a shallow water table of 5 feet or less in April, the area where the salinity of the shallow groundwater is 12 deciSiemens per meter, and the general soil characteristics (soil salinity, soil permeability, and soil depth). These factors were analyzed and a judgment was made as to the area requiring drainage. The Busch (1994) area was developed using groundwater elevations, soil classification maps, monitoring well hydrographs, and the geohydrology responses of monitoring wells, and based on these factors, a projection was made as to the areas requiring drainage at present and in the future. The PAR numbers were based on Reclamation's unpublished 1984 Draft Environmental Impact Statement (Reclamation 1984a). This document considered depth to water, salt accumulation in the soil, and applied water.

The depth to water that is required for arability of land and salinity control is normally taken to be about 7 feet. The area with depth to water of 10 feet or less within Westlands in April 2001 was approximately 270,000 acres. In addition, in April 2002 Kerry Arroues, Supervisory Soil Scientist, Natural Resource Conservation Service, indicated that from a soils characteristic standpoint, the area needing drainage service to maintain arability in Westlands is close to 300,000 acres. The physical characteristics in Westlands might prevent the area from increasing significantly beyond 300,000 acres in the future (Arroues, pers. comm., 2002).

Comparing and evaluating this information with the previous projections, Reclamation determined that the Busch (1994) projection more accurately estimated the current and future drainage needs in the San Luis Unit. Therefore, for purposes of this report the area that will ultimately need service within Westlands is about 298,000 acres.

Lands in the Northerly Area have been drained and therefore have had drainage service for many years. Currently, approximately 48,000 acres within the Northerly Area have drainage systems installed. Conversations with landowners within this area were used as a basis to predict that by 2050, 81,000 acres will need drainage service. These areas are shown in Table 2.2-3.

Table 2.3-3
Current Projections of Area Needing Drainage Service:
Northerly Area

District	Area (acres)
Broadview Water District*	10,000
Camp 13 Drainage District	6,000
Charleston Drainage District*	3,000
Firebaugh Canal Water District	24,000
Pacheco Water District*	5,000
Panoche Water District*	27,000
Panoche Drainage District not in Panoche Water District	6,000
Total	**81,000**
Total in San Luis Unit**	**45,000**

* Districts within the San Luis Unit.
** Total acreage in the San Luis Unit within the Northerly Area.

2.3 DRAINAGE SYSTEMS INSTALLED BY 2050

Reclamation determined that 53,000 acres currently have drainage systems installed in the study area. Table 2.3-1 shows areas with drainage systems installed by 2002. It is reasonable to expect that not all of the areas in the drainage service area within the Northerly Area and within

Westlands would have on-farm drainage systems installed by 2050. Some farmers would elect not to install drains based on specific site conditions and economic considerations. Therefore, Reclamation estimated that two-thirds of the area in the drainage service area (254,000 acres) would actually have subsurface drainage systems installed by 2050. Table 2.3-2 shows the projection of areas with drainage systems installed by 2050.

Table 2.3-1
Drainage Systems Installed, 2002

District	Area (acres)
Westlands North	5,000
Westlands Central	0
Westlands South	0
Subtotal (Westlands Water District)	5,000
Northern San Luis Unit Districts	30,000
Northerly Area Outside of San Luis Unit	18,000
Subtotal (Northerly Area)	48,000
Total	**53,000**

Table 2.3-2
Projection of Drainage Systems
Installed by 2050

District	Area (acres)
Westlands North	68,000
Westlands Central	70,000
Westlands South	62,000
Subtotal (Westlands Water District)	200,000
Northern San Luis Unit Districts	36,000
Northerly Area Outside of San Luis Unit	18,000
Subtotal (Northerly Area)	54,000
Total	**254,000**

Modeling of the drainwater flows and water table elevations indicates that arability is maintained with this condition (URS 2002).

Reclamation estimated the timing of the installation of drainage systems. It is unlikely that wholesale installation of new systems would occur within Westlands when drainage service is provided. The cost to install the systems is considerable, and a farmer would need to be able to justify the capital outlay. For Westlands, Reclamation estimated that once drainage service is available, the existing 5,000 acres would connect immediately, within 1 year another 5,000 acres would be installed, within 10 years another 40,000 acres, and by 2050 another 145,000 acres would come on line, for a total of 200,000 acres. For the Northerly Area, Reclamation estimated a straight line buildup from the current 48,000 acres drained to 54,000 acres in 2050.

SECTIONTHREE

DRAINAGE QUANTITY AND QUALITY AND DRAINWATER REDUCTION

Reclamation evaluated three factors affecting drainage quantity and quality:

- Which lands will ultimately need drainage to maintain arability of the soil
- The rate at which water will need to be drained off the fields to maintain arability of the soil
- What reasonable on-farm and in-district drainwater reduction actions could be implemented

DRAINAGE SERVICE

For the purposes of the Re-evaluation, Reclamation has defined drainage service as removing water from irrigated fields to maintain long-term, sustainable salt and water balance in the root zone of irrigated lands. To design and construct the appropriate facilities required for removing the drainwater, Reclamation developed an estimate of the quantity and quality of the drainwater.

Using modeling of groundwater conditions and agricultural productivity, Reclamation identified the lands that would require drainage service, the rate at which farmers would install tile drains to collect drainwater, and the rate at which water would need to be drained from the fields to maintain arability.

Reclamation then evaluated the potential drainwater reduction actions that could be implemented on-farm, in-district, or as regional facilities. **Reclamation determined that regional drainwater reuse facilities would be a cost-effective measure for reducing the volume of drainwater for treatment and disposal and should be included in all alternatives.** Reuse facilities irrigate salt-tolerant crops with unblended drainwater.

To determine the quantity and quality of drainwater the collection and reuse systems would receive from farms and water districts (and therefore the size of the facilities), Reclamation identified additional on-farm or in-district drainwater reduction actions that would be more cost-effective than drainwater collection, reuse, treatment, and disposal. That is, Reclamation identified the drainwater reduction measures for which the cost of reducing an acre-foot of drainwater would be less than the cost of collecting, reusing, treating, managing, and disposing of that acre-foot of drainwater. To size the drainwater collection, reuse, treatment, and disposal facilities, Reclamation assumed that farmers and/or water districts would implement those actions that would be cost-effective. Farmers and water districts would have flexibility to select other measures to reduce drainwater if they determine these measures to be more cost-effective.

Reclamation found three drainwater reduction measures to be cost-effective: drainwater recycling, shallow groundwater management, and seepage reduction. In addition, it was determined that the storage capacity of the groundwater aquifer beneath the reuse facilities could be used to regulate the seasonal variations in drainwater flows. Based on this analysis, Reclamation developed revised drainage quantities and flow rates, which were used in sizing facilities for all of the action alternatives. Table 3-1 shows the drainwater reduction and the resulting drainwater quantity. The difference in drainage output between the In-Valley and Out-of-Valley Disposal options is due to the presence of evaporation ponds and associated mitigation facilities in the In-Valley Disposal Alternative.

Sections 3.1 through 3.4 describe the selection of the drainwater reduction measures and the estimate of the drainwater quantity and quality for collection, treatment, and disposal. Section 3.5 presents how land retirement is being addressed in the Re-evaluation.

Table 3-1
Drainwater Reduction

	Out-of-Valley Disposal (AF/year)	In-Valley Disposal (AF/year)
Drainage Flow Without Reduction	141,700	138,900
Drainage Flow with Drainwater Reduction Activities (drainwater recycling, shallow groundwater management, and seepage reduction)	108,900	106,700
Drainage Flow with Drainwater Reduction and Regional Reuse Facilities	29,400	28,800
Average Design Flow with Drainwater Reduction and Regional Reuse Facilities	41 cfs	40 cfs

AF=acre-feet
cfs = cubic feet per second

3.1 DRAINAGE RATES AND PRELIMINARY FLOWS

3.1.1 Preliminary Drainage Rates for Alternatives Selection

For refining preliminary alternatives, Reclamation used flows based on the preliminary drainage rates described in the PAR. The PAR identified two drainage rates of 0.3 and 0.5 acre-feet (AF)/acre. The 0.3 AF/acre rate represents conditions with highly efficient on-farm irrigation systems and aggressive drainwater reduction management, and is equivalent to a design flow rate of 100 cubic feet per second (cfs). The 0.5 AF/acre rate is intended to represent traditional drainage system capacity (PAR, page ES-3) and is equivalent to a flow rate of 166 cfs. With adjustments for seasonal peaks in drainage the design flow is 300 cfs. These numbers are meant to represent the lowest and the highest reasonable rates that would result with drainage service.

3.1.2 Drainage Rates and Preliminary Flows for Drainwater Reduction Optimization

The drainage rates in the PAR were compared with drainage rates from other similar areas, including historical calculations of drainage rates in the PAR, the SJVDP Rainbow Report (SJVDP 1990) and backup documents, *Plan Formulation Appendix: San Luis Unit Drainage Program* (CH2M Hill 1991), *Special Report on Drainage and Water Service* (Reclamation 1984b), Northerly Area information, and Westlands information. For comparison, the drainage rates for the Tulare Lake area have consistently averaged 0.5 AF/drained acre (Roger Reynolds, Summers Engineering, pers. comm., May 2002). Measured drainage rates within the Northerly Area averaged 0.6 AF/drained acre in 1999. Rates within the Northerly Area varied from 0.5 AF/acre to over 1 AF/acre in some areas. In addition, the collection system within the Northerly Area is composed of deep open channels, which results in collection of additional regional groundwater during the collection and transport in the system. This collection system provides increased yield beyond the production of subsurface drainage.

In contrast, future collection systems to be built in Westlands as a part of this project are anticipated to be closed pipes, which would reduce the collection of regional groundwater during transport. Soil leaching requirements (to maintain low soil salinity in the crop root zone) within the drainage service area are calculated to range from 0.11 AF/acre using water directly from the San Luis Canal to 0.2 AF/acre under the assumption that some drainwater is recycled (White Paper 2 from Source Control Memorandum [URS 2002]).

Table 3.1-1 shows the projected drainage rates and flows for each subarea's drainage-impaired lands, including the amount collected in the deep open drains. The rate for the Northerly Area (0.6 AF/acre) is based on actual rates for the existing drainage systems. The rate for Westlands (0.5 AF/acre) is a projection, taking into consideration the above information. Reclamation used these drainage rates and preliminary flows to evaluate the cost-effectiveness of several drainwater reduction measures.

Table 3.1-1
Drainage Rates and Preliminary Flows

District	Drained Area (acres)	Drainage Rates (AF/foot)	Deep Collection System Contribution (AF/year)	Drainwater (AF/year)
Northerly Area	54,000	0.6	15,400	47,800
Westlands North	68,000	0.5	0	34,000
Westlands Central	70,000	0.5	0	35,000
Westlands South	62,000	0.5	0	31,000
TOTAL	**254,000**		**15,400**	**147,800**

3.2 DRAINWATER REDUCTION OPTIMIZATION

3.2.1 Drainwater Reduction Options

Drainwater reduction measures are intended to reduce the drainwater flow for disposal. Drainwater reduction measures may be applicable on farm or regionally. The Source Control Memorandum (URS 2002) identified a list of possible drainwater reduction options. These are:

1. **Drainwater Recycling.** Reapplying drainwater and mixing it with freshwater for crop irrigation. This option can be undertaken by an individual farm or on a district wide basis. This option reduces the amount of drainwater after it leaves the subsurface drainage systems and before disposal.
2. **Shallow Groundwater Management.** Controlling the discharges and water depths from subsurface tile drainage systems so that a portion of irrigation deep percolation is retained in the soil and is available to contribute to crop evapotranspiration (ET). This option reduces the amount of deep percolation that becomes drain water.
3. **Seepage Reduction.** Lining or piping of existing unlined irrigation conveyance and distribution facilities to reduce seepage losses. This option tends to reduce recharge to the shallow aquifer, thereby reducing the quantity and/or postponing the need for artificial drainage.

4. **Shallow Groundwater Pumping.** Pumping groundwater from aquifers that overlie more impermeable layers. This option tends to lower shallow water tables and reduce the quantity and/or postpone the need for artificial drainage in affected areas.
5. **On-Farm Irrigation Systems and Management.** Improving the uniformity and timing of irrigation to reduce deep percolation. This option tends to reduce the quantity and/or postpone the need for artificial drainage in affected areas by reducing recharge to the shallow aquifer.
6. **Annual Fallowing.** Similar to land retirement (changing from irrigated to nonirrigated land uses over the long term so that irrigation deep percolation and the need for drainage is totally eliminated on selected lands) but implemented on an annual basis by willing parties. This option would reduce the irrigated acreage and therefore the deep percolation under the fallowed land. This option would tend to reduce recharge to the shallow aquifer, thereby reducing the quantity of and/or delaying the need for artificial drainage. Water that would have been used on these lands would be reallocated within the appropriate district.
7. **Reuse/Drainwater Management.** Using drainwater as an irrigation supply for salt-tolerant crops. The lands would need to be drained. This option would reduce the volume of drainwater requiring disposal. This option could be implemented by the individual farm or on a regional basis. Furthermore, the reuse facility may be used as an underground regulating reservoir to control the flow of reused drainwater to subsequent features.

Options 2 and 5 are on-farm drainwater reduction measures, Options 3 and 6 are regional drainwater reduction measures, and Options 1 and 7 are post-drain measures.

Reclamation evaluated the effect of each drainwater reduction measure on the drainage quantity and the cost of implementation to determine the most cost-effective combination of drainwater reduction measures for each disposal alternative. Tables A-1 through A-6 in Appendix A show this cost and flow analysis. The estimated reduction in drainwater flow for each of the drainwater reduction options is shown in Table A-1. All drainwater reduction measures have been shown as if they were fully implemented for each of the drainage subareas. Although drainwater reduction was estimated for each subarea individually, the selection of the most cost-effective combination of drainwater reduction measures looked at the entire study area.

MOST COST-EFFECTIVE MEASURES

The costs per acre-foot of drainwater reduction show that reuse ($58.36/AF reduced) is by far the most cost-effective measure, with seepage reduction ($125.08/AF reduced) ranked second.

Table A-1 also shows the estimated costs for each of the drainwater reduction measures developed to use as a basis for comparison. To develop these costs, previous information was heavily relied on and in many cases, unit costs were inflated from these previous estimates for use in the developing the costs. The costs have been developed from the initial capital cost and subsequent annual operation and maintenance (O&M) costs. The capital costs were annualized and added to the annual O&M costs to obtain the annual equivalent cost of each drainwater reduction option. Table A-1 also shows the annual equivalent cost per acre of impaired land and per acre-foot of drainwater reduction savings.

3.2.2 Drainwater Reduction Scenarios

Based on a preliminary evaluation of their cost-effectiveness (see Table A-1), Reclamation developed the following 10 scenarios for evaluation with each disposal alternative:

A. No drainwater reduction, no reuse

B. Full Reuse

C. Reuse + Recycling

D. Reuse + Recycling + Shallow Groundwater Management

E. Reuse + Recycling + Seepage Reduction

F. Reuse + Recycling + Shallow Groundwater Management + Seepage Reduction

G. Reuse + Recycling + Shallow Groundwater Management + Seepage Reduction + Groundwater Pumping

H. Reuse + Recycling + Shallow Groundwater Management + Seepage Reduction + Groundwater Pumping + Irrigation System Improvements

I. Reuse + Recycling + Shallow Groundwater Management + Seepage Reduction + Groundwater Pumping + Irrigation System Improvements + Annual Fallowing

J. Reuse + Recycling + Shallow Groundwater Management + Seepage Reduction + Groundwater Pumping + Annual Fallowing

As indicated above, reuse was found to be the most cost-effective alternative and was included in all drainwater reduction combinations.

Table A-2 shows the flow reduction and cost for each of these drainwater reduction combinations. Since the lands required for the reuse facility will be located within the drained-impaired lands, the size of this facility will affect the drainwater flow. Similarly, the size of the reuse facility is determined by the influent flow. The estimation of the flows under each drainwater reduction scenario needs to be an iterative process to account for this interdependence. Consistent with the assumption made in the determination of the drainage areas (see Section 2), Reclamation estimated that 67 percent of the reuse facilities would be located within areas with drains installed by 2050. Table A-2 shows this iterative process and the resulting flows for each drainwater reduction’s combinations. The potential use of the reuse facility as an underground regulating reservoir (discussed in more detail in Section 3.3.4) eliminates the need for a peak factor to account for the peak irrigation months.

3.2.3 Drainwater Reduction Optimization For Out-of-Valley Disposal

To select the optimum combination of drainwater reduction measures for the Out-of-Valley Disposal Alternatives, the annual equivalent disposal costs for 300, 100, and 0 cfs were calculated and used for interpolation. The annual conveyance and disposal costs for the resulting flows for each of the drainwater reduction combinations were calculated by interpolating linearly between 0 and 100 cfs. The disposal cost for the no drainwater reduction option was calculated by interpolating linearly between 100 and 300 cfs. The total annual equivalent cost for disposal was added to the annual equivalent drainwater reduction cost for each scenario. In addition, normalized costs were calculated for each scenario to facilitate the comparison: cost per acres of irrigated lands, costs per acre of impaired lands, and costs per acres of impaired and irrigated lands adjusted for land required for reuse and treatment facilities (for the Delta Disposal Alternatives only).

Ocean Disposal Alternative

Table A-3 shows the costs for disposal and drainwater reduction for the Ocean Disposal Alternative. A slope factor of $211/AF/year was calculated for the 204 cfs disposal flow. A slope factor of $504/AF/year was calculated for all other disposal flows.

As shown in Table A-3, Scenario E (reuse, drainwater recycling, and seepage reduction) is the most cost-effective option, but Scenarios C (reuse with drainwater recycling) and F (reuse with drainwater recycling, shallow groundwater management, and seepage reduction) are within less than 1 percent of the total annual costs of Scenario E, and have very similar normalized costs. Therefore, for the Ocean Disposal Alternative, **Scenario F was selected to maintain the option of implementing all three drainwater reduction measures in addition to reuse**. The resulting preliminary flow rate is 39 cfs. This flow rate was refined as described below in Section 3.3.5 to calculate the design flow for the Ocean Disposal Alternative.

Delta Disposal Alternatives

Tables A-4a and A-4b show the costs for disposal and drainwater reduction for the Delta-Chipps Island Disposal Alternative for lagoon and high rate Se treatment (see Section 5), respectively. A slope factor of $128/AF/year was calculated for the 204 cfs disposal flow. A slope factor of $429/AF/year was calculated for all other disposal flows. Tables A-5a and A-5b show the costs for disposal and drainwater reduction for the Delta-Carquinez Strait Disposal Alternative for lagoon and high rate Se treatment, respectively. A slope factor of $401/AF/year was calculated for the 204 cfs disposal flow. A slope factor of $819/AF/year was calculated for all other disposal flows.

As shown in Tables A-4a and A-4b, Scenario F (reuse, drainwater recycling, shallow groundwater management, and seepage reduction) is the most cost-effective option for the Delta-Chipps Island Disposal Alternative, but Scenarios D (reuse, drainwater recycling, and shallow groundwater management) and E (reuse, drainwater recycling, and seepage reduction) are within less than 1 percent of the total annual costs of Scenario F, and have very similar normalized costs. Therefore, **Scenario F was selected to maintain the option of implementing all three drainwater reduction measures in addition to reuse**. The resulting preliminary flow rate is 39 cfs. This flow rate will be refined as described below in Section 3.3.5 to calculate the design flow for the Delta-Chipps Island Disposal Alternative.

As shown in Tables A-5a and A-5b, **Scenario F (reuse, drainwater recycling, shallow groundwater management, and seepage reduction) is the most cost-effective option for the Delta-Carquinez Strait Disposal Alternative** and, therefore, was selected. The resulting preliminary flow rate is 39 cfs. This flow rate was refined as described below in Section 3.3.5 to calculate the design flow for the Delta-Carquinez Strait Disposal Alternative.

3.2.4 Drainwater Reduction Optimization For In-Valley Disposal

For the In-Valley Disposal Alternative, the unit costs developed as part of the In-Valley Disposal Alternative screening process were used to select the optimum combination of drainwater reduction measures. These units costs were applied to each of the disposal flows to come up with the annual equivalent disposal cost for each flow scenario. The total annual equivalent cost for disposal was added to the annual equivalent drainwater reduction cost for each scenario. In addition, normalized costs were calculated for each scenario to facilitate the comparison: cost per acres of irrigated lands, costs per acres of impaired lands, and costs per acre of impaired and irrigated lands adjusted for land retired for reuse, treatment, and evaporation ponds.

Tables A-6a and A-6b show the costs for disposal and drainwater reduction for the In-Valley Disposal Alternative for lagoon and high rate Se treatment (see Section 5), respectively.

- As shown in Table A-6a, Scenario E (reuse, drainwater recycling, and seepage reduction) is the most cost-effective option for lagoon treatment, but Scenarios C (reuse and recycling), D (reuse, drainwater recycling, and shallow groundwater management), and F (reuse, drainwater recycling, shallow groundwater management, and seepage reduction) are within less than 1 percent of the total annual costs of Scenario E, and have very similar normalized costs.
- As shown in Table A-6b, Scenario F (reuse, drainwater recycling, shallow groundwater management, and seepage reduction) is the most cost-effective option for high rate treatment, but Scenarios D (reuse, drainwater recycling, and shallow groundwater management) and E (reuse, drainwater recycling, and seepage reduction) are within less than 1 percent of the total annual costs of Scenario F and have very similar normalized costs.

Therefore, for the In-Valley Disposal Alternative, **Scenario F was selected to maintain the option of implementing all three drainwater reduction measures in addition to reuse**. The resulting preliminary flow rate is 39 cfs. This flow rate was refined as described below in Section 3.3.5 to calculate the design flow for the In-Valley Disposal Alternative.

3.3 SELECTED DRAINWATER REDUCTION MEASURES AND DRAINAGE QUANTITY

DRAINWATER REDUCTION

In summary, drainwater reduction measures and reuse facilities reduce drainwater quantity by 110,088 AF/year for the In-Valley Disposal Alternative and 112,241 AF/year for Out-of-Valley Disposal Alternatives. The resulting drainage quantities to be disposed of are 29,400 AF/yr (41 cfs) for the Out-of-Valley Disposal Alternatives and 28,800 AF/yr (40 cfs) for the In-Valley Disposal Alternative.

Based on the analysis described in Section 3.2, three drainwater reduction measures have been selected in addition to reuse: shallow groundwater management, seepage reduction, and drainwater recycling. Tables 3.3-1a and 3.3-1b present for each subarea the estimated drainwater quantity reduced by each of these measures as well as the drainwater quantity for disposal after drainwater reduction for Out-of-Valley and In-Valley Disposal, respectively.

Drainwater reduction values and drainage flow were adjusted from those values reported in the Source Control Memorandum (URS 2002) to account for the lands taken out of production as part of the alternative implementation. This adjustment process is described in more detail in Section 3.3.5 and Appendix A.

Table 3.3-1a
Drainwater Reduction for Out-of-Valley Disposal

Area	Drained Acreage	Drainwater Flow (AF/yr)	Drainwater Reduction: Drainage Recycling (AF/yr)	Drainwater Reduction: Shallow Groundwater Management (AF/yr)	Drainwater Reduction: Seepage Reduction (AF/yr)	Drainwater Reduction: Reuse (AF/yr)	Drainwater Reduction: Total Drainwater Reduction (AF/yr)	Drainwater Flow After Reduction Measures (AF/yr)	Drainwater Flow After Reduction Measures (cfs)
Westlands North	63,700	31,900	4,800	1,500	0	18,700	25,000	6,900	10
Westlands Central	65,700	32,900	5,800	1,500	0	18,600	25,900	7,000	10
Westlands South	58,200	29,100	5,200	1,400	0	16,500	23,100	6,000	8
Westlands Total	187,600	93,900	15,800	4,400	0	53,800	74,000	19,900	28
Northerly Area	54,000	47,800	8,000	400	4,200	25,700	38,300	9,500	13
Total Westlands & Northerly Area	241,600	141,700	23,800	4,800	4,200	79,500	112,300	29,400	41

Table 3.3-1b
Drainwater Reduction for In-Valley Disposal

Area	Drained Acreage	Drainwater Flow (AF/yr)	Drainwater Reduction: Drainage Recycling (AF/yr)	Drainwater Reduction: Shallow Groundwater Management (AF/yr)	Drainwater Reduction: Seepage Reduction (AF/yr)	Drainwater Reduction: Reuse (AF/yr)	Drainwater Reduction: Total Drainwater Reduction (AF/yr)	Drainwater Flow After Reduction Measures (AF/yr)	Drainwater Flow After Reduction Measures (cfs)
Westlands North	59,900	30,000	4,500	1,400	0	17,600	23,500	6,500	9
Westlands Central	64,600	32,300	5,700	1,500	0	18,300	25,500	6,800	9
Westlands South	57,700	28,800	5,100	1,400	0	16,300	22,800	6,000	8
Westlands Total	182,200	91,100	15,300	4,300	0	52,200	71,800	19,300	27
Northerly Area	54,000	47,800	8,000	400	4,200	25,700	38,300	9,500	13
Total Westlands & Northerly Area	236,200	138,900	23,300	4,700	4,200	77,900	110,100	28,800	40

A schematic of the implementation of the drainwater reduction measures is shown on Figure 3.3-1. A description of each of the measures is included in the following four subsections:

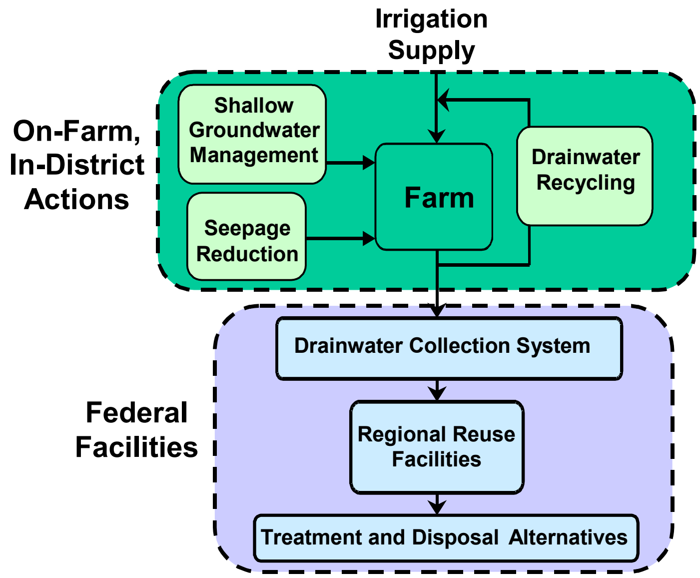


Figure 3.3-1 Common Elements to All Disposal Alternatives

3.3.1 Regional Drainwater Recycling

Based on the recent success of drainwater recycling systems in maintaining acceptable water quality for irrigation in several Northerly Area districts, recycling systems could be implemented throughout the San Luis Unit. The California Aqueduct (total dissolved solids [TDS] = 200 parts per million [ppm]) may supply freshwater for the Westlands while both the Delta-Mendota Canal (TDS = 270 ppm) and the California Aqueduct may supply the Northerly Area. This freshwater will be blended with recycled drainwater such that the blended water contains less than 600 ppm TDS to maintain crop productivity. The recycling systems could deliver drainwater to 75 percent of the irrigated area, including lands outside of the drainage-impacted area. Drainwater is only recycled during the regular irrigation season (June through September). Recycled drainwater would replace an equivalent amount of freshwater supply. The infrastructure of the drainwater recycling system consists of pumping plants and pipelines to convey drainwater back to farms. It would be similar to the recycling system currently operating in Panoche Drainage District.

The average annual water requirement for all croplands in the San Luis Unit is 2.6 AF/acre; of that 2.6 AF/acre, recycled drainwater would comprise between 0.05 and 0.06 AF/acre in Westlands and 0.11 AF/acre in the Northerly Area. Table 3.3-2 shows the monthly and annual total recirculated drainwater for the Northerly Area and the three Westlands subareas as reported in the Source Control Memorandum (URS 2002).

Table 3.3-2
Maximum Recycled Drainwater by District

	Applied Water (AF/acre)	Drainwater TDS (ppm)	Recycling Area (acres)	Maximum Annual Recycled Drainwater (AF/acre)	Maximum Annual Recycled Drainwater (AF)
Westlands North	2.6	8700	102,000	0.05	5,100
Westlands Central	2.6	8400	104,000	0.06	6,200
Westlands South	2.6	8000	92,000	0.06	5,500
Northerly Area	2.6	4700	73,000	0.11	8,000

The quantity of drainwater reduction through recycling shown in Table 3.3-2 was adjusted to account for the areas taken out of production for reuse facilities, treatment, evaporation ponds, and mitigation complexes, as applicable for each disposal alternative. The adjusted drainwater reduction for each of the drainage subareas is presented in Tables 3.3-1a and 3.3-1b for Out-of-Valley and In-Valley Disposal Alternatives, respectively. **Excluding reuse, of the drainwater reduction measures selected, recycling provides the largest reduction in drainwater quantity (23,800 AF/year for Out-of-Valley Disposal and 23,300 AF/year for In-Valley Disposal).**

3.3.2 Shallow Groundwater Management

Shallow groundwater management reduces the volume of drainwater by raising the water table to encourage crops to use shallow groundwater. The water table is raised through the installation of a network of shallow subsurface drains (4 to 5 feet below the surface). While research on shallow groundwater usage by crops is limited, successful tests on cotton and tomatoes imply that crops with comparable root depth and equal or greater salt tolerance will utilize shallow groundwater to a similar extent.

Shallow groundwater drain systems require significantly more management and monitoring and cost more than conventional drainage. Though shallow groundwater management can be controlled to prevent salt accumulation in the upper soil layer, salt may accumulate in the lower profile (below the upper foot) due to the increase in soil water evaporation in the raised water table. If salt and/or Se accumulation becomes problematic, additional management such as soil leaching may be required.

The quantity of drainwater reduction through shallow groundwater management was modeled in the Source Control Memorandum (URS 2002) using the following assumptions:

- Ten percent of the farmers in the Northerly Area and 25 percent of the farmers in Westlands are willing to farm in a way that uses shallow groundwater.
- Crops would only use shallow groundwater after the plants have matured and developed enough root depth (approximately June through September).
- All of the drained lands within the drainage service area can be operated (or modified to operate) with shallow groundwater management. Lands outside of the drainage service area would not be managed using shallow groundwater.

- The cropping pattern is evenly distributed so that the percentages of the crop types located within the drainage service area are the same as the crop type percentages located in the districts.
- Seventy-five percent of the volume of groundwater consumed by the crops is removed from the volume of drainwater that needs to be discharged to account for the additional leaching required for salt management.

The modeling results were adjusted to account for the areas taken out of production for reuse facilities, treatment, evaporation ponds, and mitigation complexes, as applicable for each disposal alternative. The adjusted drainwater reduction for each of the drainage subareas is presented in Tables 3.3-1a and 3.3-1b for the Out-of-Valley and In-Valley Disposal Alternatives, respectively. Shallow groundwater management reduces the drainwater quantity by 4,800 AF/year for the Out-of-Valley Disposal Alternatives and 4,700 AF/year for the In-Valley Disposal Alternative.

3.3.3 Seepage Reduction

An inventory of San Luis Unit irrigation districts in 1990 found that approximately 77 miles of water delivery canals were unlined, resulting in an annual seepage loss of 9,400 AF (Source Control Memorandum [URS 2002]). It is projected that the lining of the canals with concrete would significantly reduce the seepage loss to approximately 1,000 AF/year. In addition to reduced seepage loss, O&M costs for lined canals are less than for unlined canals. Because seepage loss in unlined channels is not significant in Westlands (the conveyance is primarily pipelines), only the Northerly Area will benefit from seepage reduction. In addition, because half of the unlined canals occur in nondrainage-impacted lands only a portion of the reduction in seepage loss would result in less drainwater production.

The estimated drainwater reduction accomplished by seepage reduction is presented in Tables 3.3-1a and 3.3-1b for Out-of-Valley and In-Valley Disposal, respectively. Seepage reduction reduces the drainwater quantity by 4,200 AF/year for both Out-of-Valley and In-Valley Disposal Alternatives.

3.3.4 Reuse

Reuse facilities involve the irrigation of salt-tolerant crops with unblended drainwater.

Description

Two modes of operation for reuse facilities were analyzed: (1) single-phase application and (2) sequential reuse. A single-phase reuse facility would be cropped entirely with salt-tolerant pasture or crops to be irrigated with unblended drainwater. The pasture seed mix would contain species that can tolerate water with a TDS of up to 10,000 ppm. A sequential reuse facility would be split into two zones: a region planted with typical salt-tolerant crops (tolerant to a TDS of 10,000 ppm ±) and a region planted with very salt-tolerant crops or halophytes (tolerant to a TDS of up to 20,000 ppm ±). The primary advantage of the sequential reuse system over the single-phase application is the greater reduction in drainage volume. However, potentially higher concentrations of salt, Se, and boron resulting from the sequential reuse may be more costly to treat. As a result, the single-phase application was selected. Crops such as atriplex or salicornia will be selected to withstand root zones containing up to 10,000 ppm TDS.

Drainwater would be conveyed to the agricultural reuse facility to irrigate the salt-tolerant crops. It is estimated that drainwater would be applied at a rate of 4 AF/acre in the reuse facility with a 27 percent leaching rate. Approximately 73 percent of the original drainwater would be lost to ET. The reused drainwater would be collected in tile drains and conveyed to the treatment and disposal facilities. The water quality of the reused drainwater would be the same as the water quality of the perched aquifer beneath the reuse facility. It is expected that water quality of the perched aquifer would gradually decline during long-term use as do all aquifers underlying irrigated farmlands. Although some reuse facilities have operated and drained for several years, for the long-term operation proposed the facility will require a subsurface drainage system. For this study, it was assumed that subsurface drainage systems with control valves will be installed at a depth of approximately 7.5 feet.

A 4,000-acre reuse facility has been constructed and is currently operating in the Northerly Area as part of the GDA.

Use of Reuse Facility for Storage

Drainwater flows from commercial farms are subject to seasonal variability due to irrigation practices.[1] The storage capacity of the groundwater aquifer beneath agricultural reuse facilities could be used to regulate these seasonal variations in the drainwater flows. Valves on the drainwater collection system would be used to maintain a constant discharge flow while the water table would rise and fall in response to the varying irrigation inflows.

Average water table depth would be held at 7 feet; however, during the growing season the soil will be used as seasonal storage, raising the water table to approximately 5 feet through valves and controlling pumping at sumps. A preliminary evaluation of the storage capacity of the soils in the Northerly Area and Westlands indicates that for an assumed soil porosity of 10 percent and for drain yields reported in the Source Control Memorandum (URS 2002) the soils have enough capacity to store the additional irrigation water in the growing months (see Tables 3.3-3a and 3.3-3b for Westlands and Northerly Area, respectively). Therefore, for the proposed long-term operation of the facility, **a constant pumping rate at the average yearly flow will successfully collect the drainwater from the reuse facilities for disposal**.

Similarly, the long-term soil salinity effects of holding the shallow water table 2 feet higher during most of the growing season was evaluated using a spreadsheet version of the APSIDE model. Some of the assumptions of this preliminary analysis were:

1. Drains in the reuse area are installed at 7.5-foot depth, with control valves. Average water table depth without additional seasonal storage is about 7 feet, with the seasonal storage water table depth held to about 5 feet during the growing season.

[1] The seasonal variations for Westlands and the Northerly Area are shown on Figure 4 of the Source Control Memorandum (URS 2002).

Table 3.3-3a
Reuse Facility Storage Capacity for Westlands

Month	Yield from Drains	Application (feet)	Deep Perc (feet)	Discharge (feet)	Discharge-Deep Perc (feet)	Cum (feet)
Feb	9%	0.35	0.09	0.09	0.00	0.00
Mar	10%	0.38	0.10	0.09	-0.01	-0.02
April	10%	0.38	0.10	0.09	-0.01	-0.03
May	10%	0.41	0.11	0.09	-0.02	-0.05
June	11%	0.42	0.11	0.09	-0.02	-0.08
July	12%	0.47	0.13	0.09	-0.04	-0.11
Aug*	10%	0.39	0.11	0.09	-0.02	-0.13
Sept	6%	0.24	0.06	0.09	0.03	-0.10
Oct	4%	0.17	0.05	0.09	0.04	-0.06
Nov	4%	0.17	0.05	0.09	0.04	-0.02
Dec	7%	0.28	0.08	0.09	0.01	0.00
Jan	8%	0.33	0.09	0.09	0.00	0.00
Annual Total	**100%**	**4.00**	**1.08**	**1.08**	**0.00**	**0.00**

* August shows a 0.13-foot rise in water table from the low point in January.
Using a 10 percent storage coefficient would mean a 1.3-foot rise in the water table.
Between drains you may get another foot, so possibly a 2.3-foot rise would occur.

Table 3.3-3b
Reuse Facility Storage Capacity for Northerly Area

Month	Yield from Drains	Application (feet)	Deep Perc (feet)	Discharge (feet)	Discharge Deep Perc (feet)	Cum (feet)
Feb	9%	0.36	0.10	0.09	-0.01	-0.01
Mar	12%	0.50	0.13	0.09	-0.04	-0.05
April	10%	0.40	0.11	0.09	-0.02	-0.07
May	10%	0.38	0.10	0.09	-0.01	-0.08
June	13%	0.52	0.14	0.09	-0.05	-0.14
July	14%	0.54	0.15	0.09	-0.06	-0.19
Aug*	10%	0.41	0.11	0.09	-0.02	-0.21
Sept	6%	0.25	0.07	0.09	0.02	-0.19
Oct	4%	0.16	0.04	0.09	0.05	-0.14
Nov	3%	0.14	0.04	0.09	0.05	-0.09
Dec	4%	0.14	0.04	0.09	0.05	-0.04
Jan	5%	0.18	0.05	0.09	0.04	0.00
Annual Total	**100%**	**4.00**	**1.08**	**1.08**	**0.00**	**0.00**

* August shows a 0.21-foot rise in water table from the low point in January.
Using a 10 percent storage coefficient would mean a 2-foot rise in water table.
Between drains you may get another foot, so possibly a 3-foot rise would occur.

2. Reclamation examined two cases for the quality of drainwater applied in the reuse area:
   - Westlands: new drains are installed and drainage TDS declines significantly during early years.
   - Northerly Area: drainage TDS is fairly constant over time.
3. Reuse area crops must be able to grow well in a root zone TDS exceeding 8,000 ppm.
4. Crop ET in the reuse area is about 2.9 AF/acre; applied water of 4.1 to 4.2 AF/acre (variation depending on the "natural" rate of vertical downward movement of shallow groundwater being 0.3 to 0.4 foot/year); drainage rate from reuse area is 1.08 AF/acre (White Paper 6 from the Source Control Memorandum [URS 2002]).

The preliminary conclusion of this analysis is that seasonal storage will not have a significant impact within the reuse areas on root zone salinity, the yield of salt-tolerant crops, or drainage quality. In the case of the Northerly Area, root zone TDS is about 500 to 600 ppm higher with the extra storage; in the Westlands North case, root zone TDS is about 500 to 800 ppm higher, depending on the year after installation. Very little change occurs in the concentration of drainwater.

The potential use of the reuse facility as a regulating reservoir eliminates the need for a peak factor to account for the peak irrigation months. The design flow would then be constant and equal to the average annual flow. There are three substantial benefits in maintaining constant drainwater flow rates:

1. The required capacity of all treatment and conveyance features subsequent to the reuse facilities can be sized for the average annual flow rates, which amounts to a 33 percent reduction from the capacity that would otherwise be required to handle peak flows.
2. All energy-consuming equipment (e.g., pumps and motors) can be designed for constant energy loads, which result in reduced equipment and maintenance costs, reduced energy consumption, and less expensive energy rates compared to a variable energy demand system.
3. Surface storage, in the form of regulating reservoirs, would not be required, thus eliminating a potentially significant contaminant hazard and exposure pathway for Se by accumulation.

Impact of Reuse on Drainwater Quantity

The quantity of drainwater reduction through a single-phase reuse facility was estimated in the Source Control Memorandum (URS 2002) assuming a leaching factor of 27 percent calculated to prevent salt accumulation and maintain a salt balance in the reuse facility root zone soil. Drainwater used to irrigate reuse crops must be applied at a rate that is 27 percent in excess of the amount the reuse crops require in order to leach the root zone soil of salts. Each thousand acres of reuse facility can displace 4,000 AF/yr of drainwater and produce approximately 1,080 AF/yr of drainwater.

REUSE OF DRAINWATER

Reuse provides the largest reduction in drainwater quantity of all drainwater measures evaluated (79,500 AF/year for Out-of-Valley Disposal and 77,900 AF/year for In-Valley Disposal). Furthermore, the reuse facility could be used to regulate seasonal variations in groundwater flows. The design flow would then be constant and equal to the average annual flow.

The effect of reuse on the drainwater quality is described in Section 3.4. The quality of the reused water would change over time to be that of the applied drainwater percolating past the root zone, the quality of the discharged drainwater becomes that of the applied drainwater concentrated by the fraction leached.

The subsurface drainwater collected and discharged would initially be the perched groundwater in the region. Over time, the perched groundwater would be replaced by deep percolation of the applied drainwater (provided lateral shallow groundwater flows did not continuously replenish the perched water table).

The quantity of drainwater reduction through reuse had to be adjusted to account for the areas taken out of production for the reuse facilities, treatment, evaporation ponds, and mitigation complexes, as applicable for each disposal alternative. The adjusted drainwater reduction for each of the drainage subareas is presented in Tables 3.3-1a and 3.3-1b for Out-of-Valley and In-Valley Disposal, respectively.

3.3.5 Drainage Quantity

Drainwater quantity for disposal had to be adjusted from those values reported in the Source Control Memorandum (URS 2002) to account for the lands taken out of production as part of each alternative.

- For all disposal alternatives, the reuse facilities would be located within the drainage-impaired lands and would need to be discounted from the lands generating drainage.
- For the In-Valley Disposal Alternative, treatment, evaporation ponds, and mitigation complexes would be located within the drainage-impaired lands and would no longer produce drainwater. Therefore, the size of these facilities would impact the annual drainwater quantity and the flow reduction by drainwater reduction measures.

DESIGN FLOWS

Flows of 41 cfs for Out-of-Valley and 40 cfs for In-Valley have been used as design flows for the disposal alternatives. These flows do not include a peak factor to account for seasonal flow variability and therefore assume seasonal storage under the reuse facility (see Section 3.3.4).

Similarly, the size of the facilities is determined by the influent flows. The estimate of the flows and facility sizing requires an iterative process to account for this interdependence. Consistent with the estimates made in the determination of the drainage areas (see Section 2), for the Westlands subareas it was assumed that 67 percent of the reuse facilities would be located within areas with drains installed by 2050. For the Northerly Area, it is assumed that the facilities would not be located within areas with drains installed by 2050. Tables A-7a and A-7b in Appendix A show this iterative process and the resulting Out-of-Valley and In-Valley flows, respectively.

Contributions to subsurface drainage discharge that are caused by inputs from outside of the subareas could occur. These sources could be from Westside stream flows and other “upslope” sources. These sources have not been taken into account. The U.S. Geological Survey (USGS) is developing an update of the Belitz MODFLOW model that may address these issues.

3.4 DRAINAGE QUALITY

This section describes drainage quality without and with (before and after) the proposed reuse facilities.

3.4.1 Drainage Quality Before Reuse

Westlands Water District Drainage Quality Before Reuse

Water quality data for Westlands are available from numerous sources and are discussed in more detail in Section 4. *Report of Waste Discharge for Storage and Land Application of Subsurface Agricultural Drainage Water* (CH2M Hill 1985) reported TDS, Se, boron, and molybdenum data based upon measurements from the San Luis Drain at or near Bass Avenue in Mendota during 1981–1984. Over this time interval, however, the only drainwater originating from Westlands was from 5,000 acres in Westlands North that had installed drains, which only constitute approximately 3 percent of the eventual drained acreage planned for Westlands by 2050. Additionally, water quality data for several constituents were collected in Westlands North between 1986–1996 from shallow groundwater samples collected in sumps.

Water quality data for other Westlands subareas are available from contour mapping data reported in the Rainbow Report (SJVDP 1990). Average concentrations were obtained from these contour maps for the entire Westlands. Concentrations for other constituents have been estimated from the data for all three Westlands subareas by adjustment with a scaling factor. The scaling factor for each subarea was calculated as a ratio of the TDS concentration for each subarea from contour mapping to the average TDS concentration calculated for Westlands from the 1981–1984 data.

TDS, Se, and molybdenum concentrations were highest in Westlands North; boron concentrations were similar in all three subareas (Table 3.4-1). Other constituents of concern, particularly for Delta discharges, are copper, chromium, and cadmium. Average concentrations from the 1981–1984 Westlands sampling were 20 ppb copper, 10 ppb chromium, and <1 ppb cadmium. Average chromium and cadmium concentrations obtained from Westlands North (1986–1996) monitoring were 32 ppb chromium and 37 ppb cadmium (Table 3.4-1). This average cadmium concentration, however, is questionably large and may not be accurate.

Northerly Area Drainage Quality Before Reuse

For the Northerly Area, water in the San Luis Drain is frequently sampled as part of the Grassland Bypass Project Monitoring Program. Samples are collected at Station B, which is the discharge point of the Drain into Mud Slough. Average TDS, boron, and molybdenum concentrations were 3,223 ppm, 7,100 ppb, and 27 ppb, respectively (Reclamation 2001b). Se concentrations over the same time interval averaged 60 ppb; however, Se varied seasonally at Station B in the Drain. Peak Se concentrations occurred in April (90 ppb) and minimum concentrations occurred in August (40 ppb) (Reclamation 2001b). Copper and chromium measurements at Station B in the Drain averaged 3.4 ppb and 5.9 ppb, respectively (Reclamation 2001b). The summary of the drainwater quality data before reuse is included in Table 3.4-1.

Table 3.4-1
Summary of Drainwater Quality Data Before Reuse

Constituent	Units	Pre-Reuse Drainage						
		Report of Waste Discharge (North Westlands) Data[1]		North Westlands[2]	Central Westlands[3]	South Westlands[3]	Northerly Area[4]	San Luis Unit Flow Weighted Average
Sodium	mg/L		2,190	1,721	1,868	1,779	595	1,404
Potassium	mg/L		7	7	6	6	9	7
Calcium	mg/L		555	436	473	451	286	399
Magnesium	mg/L		270	201	230	219	93	177
Hardness	mg/L		.	.	.	.	1,092	353
Alkalinity	mg/L		195	196	166	158	170	173
Sulfate	mg/L		4,650	3,734	3,965	3,777	1,500	3,075
Chloride	mg/L		155	1,009	132	126	546	466
Nitrate(NO_3)	mg/L		213	235	181	173	44	147
Nitrate(N)	mg/L		48	53	41	39	10	33
Ammonia	mg/L		0	.	.	.	1	0
Silica	mg/L		37	37	32	30	.	22
Bicarbonate	mg/L		.	225	.	.	173	108
Carbonate	mg/L		.	.	.	.	4	1
Bromide	mg/L		.	.	.	.	2	1
TDS[5]	mg/L		9,850	9,900	8,400	8,000	3,223	6,987
TSS	mg/L		10	10	9	8	.	6
TOC	mg/L		10	10	8	8	.	6
COD	mg/L		30	30	26	24	.	18
BOD	mg/L		3	3	3	2	.	2
Temp	C		18	18	15	15	.	11
PH			8	8	7	7	8	7
Boron[5]	µg/L		15,000	12,610	13,000	13,000	7,100	8,488
Selenium[5]	µg/L		230	181	130	30	60	150
Strontium	µg/L		6,400	6,432	5,458	5,198	.	3,862
Iron	µg/L		150	151	128	122	.	91
Molybdenum	µg/L			114	96	92	27	77
Aluminum	µg/L		.	.	.	.	.	0
Arsenic	µg/L		.	3	.	.	0	3
Cadmium[6]	µg/L	<	1	37	1	1	.	9
Chromium	µg/L		20	32	17	16	6	17
Copper	µg/L		10	10	9	8	3	7
Lead[6]	µg/L	<	1	1	1	1	5	2
Manganese	µg/L		10	10	9	8	2	7
Mercury[6]	µg/L	<	0	.	.	.	0	0
Nickel	µg/L		20	20	17	16	5	14
Silver	µg/L		1	1	1	1	.	1
Zinc	µg/L		10	10	9	8	2	7

Notes:

[1]Report of Waste Discharge (Westlands North) prepared by CH2M Hill in June 1985. Averaged data from 1981-1984.

[2]Westlands North data estimated by scaling average 1985 Westlands data (see Note 1).

[3]Westlands South and Central data estimated by scaling average 1985 Westlands data (see Note 1) by ratio of TDS.

[4]Northerly Area data from Grassland Bypass Project Monitoring Program (1996-2000 from *Grassland Bypass Project EIS/ EIR* [Reclamation 2001b], 1997-2002 from SFEI.org).

[5]All Westlands subdistricts TDS and Westlands South and Central Westlands subdistricts boron and Se data from contour mapping.

[6]Westlands concentrations of lead, copper, and mercury were reported to be less than the detection limits.

3.4.2 Estimated Drainage Quality Post-Reuse

The subsurface drainwater collected and discharged from the reuse facility would initially be the perched groundwater beneath the reuse facility. Therefore, the water quality of the reused drainwater would be the same as the water quality of the perched aquifer. Over time, it is expected that the water quality of the perched groundwater would gradually change as the perched aquifer is replaced by the applied drainwater percolating past the root zone. The quality of the discharged drainwater would then become that of the applied drainwater concentrated by the fraction leached (assuming that the salt, boron, and Se mass is conserved).

To estimate the ultimate post-reuse drainwater quality, current drainwater data were scaled to account for increases in constituent concentrations through a reuse facility. Estimates of TDS, Se, and boron concentrations from reuse discharge were calculated based on an estimated 73 percent water usage volume by reuse facility crops and that all constituents are conserved. These calculations and current groundwater concentrations under the proposed locations for the reuse facilities were then averaged to account for dilution of drainage from the facility with shallow groundwater before discharge into reuse facility drains. This average resulted in calculated estimated discharge concentrations for Westlands (and its subareas) and the Northerly Area. Current data for all other constituents were then scaled by the ratio of calculated estimated TDS concentration to current TDS concentration. Table 3.4-2 summarizes the estimated post-reuse drainwater concentrations for the San Luis Unit. It should be noted that these concentrations will not be generated until final buildout of drainage service and many years of reuse facility operation, and that initial discharge quality would be dependent on the final selection of reuse facility locations.

3.5 LAND RETIREMENT

This section describes how land retirement is being addressed in the Re-evaluation. Land retirement is defined as *the removal of lands from irrigated agricultural production by purchase or lease for other purposes or land uses*. In short, agricultural land is retired from production with an assumption that irrigation activities will cease and drainage would not be produced such that these lands would not require drainage service. Land retirement affects the number of acres requiring drainage service and hence the volume and potentially the aggregate quality of drainwater produced.

Reclamation has determined that alternatives that include a land retirement component for the purpose of reducing drainwater volumes will not be included in the Re-evaluation analysis of action alternatives because land retirement does not meet the project purpose as defined by court order to provide drainage service to the San Luis Unit (Section 1.3). Land retirement currently being implemented under the CVPIA land retirement program (7,000 acres) and the Britz settlement (3,006 acres) was included in determining drainage volumes, Additionally, lands needed for project features such as reuse facilities or evaporation ponds have been factored into the drainage projections.

Land retirement of 78,406 acres is included in the No Action Alternative (Section 5.1). Most of this retired land (an estimated 68,400 acres in Westlands) would be returned to production with the provision of drainage service based on the terms of the settlement agreement under which Westlands is retiring these lands. Therefore, lands retired by Westlands are assumed to be brought back into production and provided drainage service under the action alternatives.

Table 3.4-2
Drainwater Quality Data After Reuse

Constituent	Unit	North Westlands	Central Westlands	South Westlands	Northerly Area	San Luis Unit Flow Weighted Average
Sodium	mg/L	4,172	4,669	4,447	1,451	3,467
Potassium	mg/L	18	15	14	22	18
Calcium	mg/L	1,058	1,183	1,127	698	985
Magnesium	mg/L	488	576	548	227	437
Hardness	mg/L	.	.	.	2,663	861
Alkalinity	mg/L	475	416	396	415	425
Sulfate	mg/L	9,052	9,914	9,442	3,659	7,594
Chloride	mg/L	2,447	330	315	1,332	1,138
Nitrate(NO_3)	mg/L	569	453	432	107	363
Nitrate(N)	mg/L	128	102	97	24	82
Ammonia	mg/L	.	.	.	2	1
Silica	mg/L	90	79	75	.	55
Bicarbonate	mg/L	546	0	0	422	262
Carbonate	mg/L	.	.	.	9	3
Bromide	mg/L	.	.	.	5	2
TDS	mg/L	24,000	21,000	20,000	7,861	17,231
TSS	mg/L	24	21	20	.	15
TOC	mg/L	23	20	19	.	14
COD	mg/L	73	64	61	.	45
BOD	mg/L	7	6	6	.	4
Temp	C	44	38	37	.	11
PH		19	17	17	20	7
Boron	µg/L	37,000	32,000	32,000	21,000	30,000
Selenium	µg/L	570	310	70	320	361
Strontium	µg/L	15,594	13,645	12,995	.	9,544
Iron	µg/L	365	320	305	.	224
Molybdenum	µg/L	275	241	229	66	190
Aluminum	µg/L	.	.	.	.	.
Arsenic	µg/L	7	.	.	20	8
Cadmium	µg/L	91	2	2	0	22
Chromium	µg/L	78	43	41	14	41
Copper	µg/L	24	21	20	8	18
Lead	µg/L	2	2	2	12	5
Manganese	µg/L	24	21	20	5	16
Mercury	µg/L	0	0	0	0	0
Nickel	µg/L	49	43	41	13	34
Silver	µg/L	2	2	2	0	1
Zinc	µg/L	24	21	20	6	17

Due to interest in land retirement scenarios, Reclamation evaluated three possible levels of land retirement to determine how it would affect the facilities and costs for providing drainage service (see Appendix B). Reclamation did not evaluate these land retirement scenarios as alternatives for providing drainage service; rather, Reclamation estimated the reduced quantity of drainwater that would result from these three levels of land retirement and the resulting cost reductions for drainage service facilities. The three land retirement scenarios evaluated are:

- The first scenario involves retirement of **40,000 acres** of land consistent with the **1990 Rainbow Report** (SJVDP 1990) and the **1991 San Luis Unit Drainage Report,** which identified approximately 34,000–48,000 acres for retirement within Westlands.
- The second scenario involves retirement of **200,000 acres** of land consistent with **Westlands' proposed plan** to retire land within the district.
- The third scenario **eliminates all Federal drainage service for Westlands**. One possible aspect of the Westlands land retirement proposal is that Westlands would relieve Reclamation of its obligation to provide drainage service to the district. Under this scenario, Reclamation assumed that drainage service would be provided for 81,000 acres in the Northerly Area.

For these three scenarios, Reclamation estimated the remaining quality and quantity of drainwater still requiring service from the Unit (including lands in Westlands that still require drainage) and recalculated the cost of the Federal portion of the drainage solution, including collection, conveyance, reuse, treatment, and disposal. Costs for land retirement or on-farm and in-district activities are not included. The "land retirement analysis" only assumes the retired lands will be put to a use that does not include significant application of water but does not make any assumptions regarding the following:

- The entity implementing the land retirement
- The entity that will be responsible for managing the retired lands
- How the water that would have otherwise been applied to the retired lands would be reallocated

Appendix B summarizes the costs associated with estimated changes in drainwater quantity and quality that could occur as a result of potential land retirement scenarios.

SECTIONFOUR

PLAN FORMULATION AND EVALUATION PROCESS

This section provides an overview of the formulation and evaluation of disposal alternatives and includes a description of the alternatives evaluation criteria and screening process. The alternatives selected in this preliminary screening process within each disposal concept are described in detail in Section 5.

Following publication of the Preliminary Alternatives Report in December 2001, Reclamation conducted additional analyses to develop final alternatives for evaluation and comparison. The development of alternatives focused on refining options within each of the three primary disposal concepts: In-Valley Disposal, Ocean Disposal, and Delta Disposal. The Reclamation team reviewed previous studies, conducted additional research on treatment and disposal options, developed preliminary cost and design information for facilities, and conducted field visits to potential conveyance corridors. At this time, detailed site-specific investigations have not been performed for the impact analyses.

Reclamation developed and applied screening criteria to the preliminary alternatives to assist in identifying the optimal alternative within a disposal concept. During alternative development and refinement, preliminary alternatives were only compared within a disposal concept and not compared against other disposal concepts. Based on this evaluation, Reclamation identified four complete alternatives: one In-Valley Disposal Alternative, one Ocean Disposal Alternative (Point Estero), and two Delta Disposal Alternatives (Chipps Island and Carquinez Strait).

4.1 REFINEMENT OF PRELIMINARY ALTERNATIVES

The preliminary alternatives were presented in the PAR (Reclamation 2001a). The PAR identified a wide range of preliminary alternatives for providing drainage service based on two broad initial screening criteria: an alternative must (1) meet the court order and (2) utilize proven technology. The PAR also summarized public scoping activities during 2002. The 21 alternatives in the PAR were grouped among three broad concepts: In-Valley Disposal, Out-of-Valley Disposal, and Beneficial Use.

- The In-Valley Disposal concept concerned the disposal of drainwater and salts in or near the drainage-affected area, possibly with prior treatment to remove Se or other constituents.
- The Out-of-Valley Disposal concept required the transport of drainwater to the Pacific Ocean, Delta, or San Joaquin River, possibly with treatment to remove Se or other constituents.
- The Beneficial and/or Commercial Use concept relied on the use of treated drainwater for irrigation, municipal, or other uses and the potential commercial use of removed salts.

The concept of Beneficial Use Alternatives was subsequently eliminated to reduce overlapping and redundancy among the Alternatives. It was recognized that all Beneficial Use options could be incorporated within the In-Valley and Out-of-Valley Disposal Alternatives. The most significant opportunity for beneficial use is irrigation of salt-tolerant crops (referred to as "Integrated Drainage Management" in the PAR). This reuse option can be applied to both the In-Valley and Out-of-Valley Alternatives. Likewise, any Beneficial Use Alternative would necessarily have In-Valley or Out-of-Valley features associated with it. Consequently, the alternatives listed in the PAR for the beneficial use of drainwater were repackaged into the two remaining alternative concepts.

Several of the preliminary alternatives in the PAR included components that have since been eliminated due to uncertainties regarding their technical and/or economic viability. For example, deep-well disposal would require additional field investigations to determine whether the subsurface geology has the capacity to receive and isolate injected drainwater. A determination of the potential for salt reuse would require laboratory and field testing to evaluate precipitation processes, as well as a marketing analysis of potential salt users. While these investigations have been initiated, the results are not yet available. Although these drainage service options have been eliminated from the list of alternatives, they could be reinstated in the future if the field results are positive.

Many of the preliminary alternatives in the PAR were eliminated, modified, or repackaged as a result of the decisions described below. The next stage of the evaluation process was to compare and rate the refined alternatives on the basis of cost, implementation, and expected environmental impacts.

4.2 FORMULATION OF COMPLETE ALTERNATIVES

This section focuses on the formulation of complete alternatives, including the development of a comprehensive screening process for the alternatives remaining in early June 2002, and how these were reduced to a final set of four alternatives for further evaluation in this Plan Formulation Report. It explains how the 21 sub-alternatives from the PAR were further investigated, refined, and reorganized into complete, stand-alone alternatives that were screened using specific evaluation criteria. The initial focus of the PAR was on a broad range of alternatives meeting two broad criteria (see Section 4.1). Between December 2001 and June 2002, site visits and additional public scoping helped the Project Team to develop more specific evaluation criteria and apply those criteria to reduce the number of alternatives requiring further evaluation.

4.2.1 Alternatives Evaluated

The remaining alternatives (within each disposal concept [January–May 2002]) were evaluated for two different drainwater flow scenarios derived from two different drainage rates. A drainage rate of 0.3 AF/acre of irrigated land was used to represent the drainwater yield assuming a variety of drainwater reduction measures were implemented. A drainage rate of 0.5 AF/acre of irrigated land was used to represent the drainwater yield assuming no drainwater reduction measures were implemented.

Costs are associated with implementation of drainwater reduction measures and these costs were added to the overall costs of the alternatives that were evaluated under the 0.3 AF/acre drainage rate scenario. The following sections describe the remaining alternatives within each disposal concept presented for screening at the June 2002 workshop.

4.2.1.1 Ocean Disposal Alternatives

After completion of the PAR, two general locations were considered along the California coast in the Pacific Ocean for the Ocean Disposal Alternative. Shown on Figure 4.2-1, these two locations have different aqueduct and disposal requirements. One location is near Needle Point and the other is near Point Estero. The Needle Point location is a few miles west of the city of

Figure 4.2-1 Preliminary Ocean and Delta Alternatives

Santa Cruz and 2.53 miles offshore. The diffuser would be within the Monterey Bay National Marine Sanctuary. Point Estero is about 120 miles south of the Needle Point site and located nearly 10 miles outside the southern boundary of the Monterey Bay National Marine Sanctuary.

Common elements for each of the outfall options included using the existing San Luis Drain as a right-of-way (ROW), piping the drainwater through/over the Coast Ranges, and discharging the water in the ocean. To the extent possible, existing ROWs and conveyance facilities would be used. Outfall locations were identified from the Brown and Caldwell (1987) report. Monterey Bay was eliminated as a potential site since State law prohibits disposal of San Luis drainwater into the Bay. The Brown and Caldwell (1987) report clearly identifies locations that could receive drainwater.

Criteria for selecting the depth and offshore distance of the ocean outfall locations were:

- Ocean currents
- Drainwater to ocean temperature differential
- Depth of the discharge pipe
- Impacts to marine life
- Water chemistry

The Needle Point aqueduct would intercept the drainwater in the existing San Luis Drain a few miles east of Los Banos, near Highway 152. From the intake, the aqueduct would proceed westerly to Monterey Bay. There are three potential routes as the aqueduct approaches the Monterey Bay. One route conveys the drainwater through the city of Santa Cruz in a pipeline, the second uses a tunnel under the bay between the shore and the diffuser, and the third route uses a pipeline suspended off the bay floor to the diffuser. All of these alternatives discharge their waters into the Monterey Bay National Marine Sanctuary.

The density of drainwater (including reused drainwater) was within acceptable limits for discharge into the ocean. The Se levels of the discharge water would also fall within discharge limits with the application of dilution credits. Finally, the size of the elements of each ocean disposal option may change with varying quantities of discharge (0.5 vs. 0.3 AF/acre of drainage).

4.2.1.2 Delta Disposal Alternatives

After publication of the PAR, two Delta Disposal Alternative locations were examined: Chipps Island and Carquinez Strait. Shown on Figure 4.2-1, these alternatives include an extension of the existing San Luis Drain for collecting drainwater, construction of an Se biotreatment facility, construction of a pipeline from the current terminus of the Drain to a point in the San Francisco Bay Area (eastern Contra Costa County), and providing an outfall location at Chipps Island or in the Carquinez Strait (at Crockett). Elements of each alternative are essentially the same with the difference being an extension of the Drain from the Chipps Island vicinity to the Carquinez Strait location. Permitting requirements for each location are the same.

The Carquinez Strait location was considered for three reasons:

- It avoids critical Suisun Marsh habitat.

- It avoids municipal water inlets near Antioch.
- It has greater tidal action and Delta outflow when compared to the Chipps Island location.

However, the Chipps Island location was also maintained for further evaluation.

4.2.1.3 In-Valley Disposal Alternatives

None of the In-Valley Disposal Alternatives discussed in the PAR was eliminated by June 2002; however, they were modified to incorporate the beneficial use concepts that were shown as a separate alternative in the PAR. The six remaining In-Valley Disposal Alternatives are described below. A flow chart schematic of these alternatives is provided in Figure 4.2-2.

- **Alternative A.** Drainwater from all zones is conveyed and discharged to evaporation ponds. Dried salts are disposed in place at the end of project. Drainwater quality remains stable during the life of the project. Average Se concentration of the combined drainwater going into the evaporation ponds is about 150 parts per billion (ppb). Mitigation wetlands are constructed to offset the environmental damage caused by Se in the exposed evaporation ponds.
- **Alternative B.** Low-Se (<50 ppb) drainwater from Westlands South (about 25 percent of total drainwater) is discharged directly to evaporation ponds. Drainwater from all other zones is treated biologically to remove Se to a concentration below 50 ppb and subsequently discharged to evaporation ponds. This alternative has less environmental damage than Alternative 1 since the Se concentration of all drainwater that flows into the evaporation ponds is below 50 ppb. Alternative B has the added cost of biological treatment but a lower cost for mitigation compared to Alternative A.

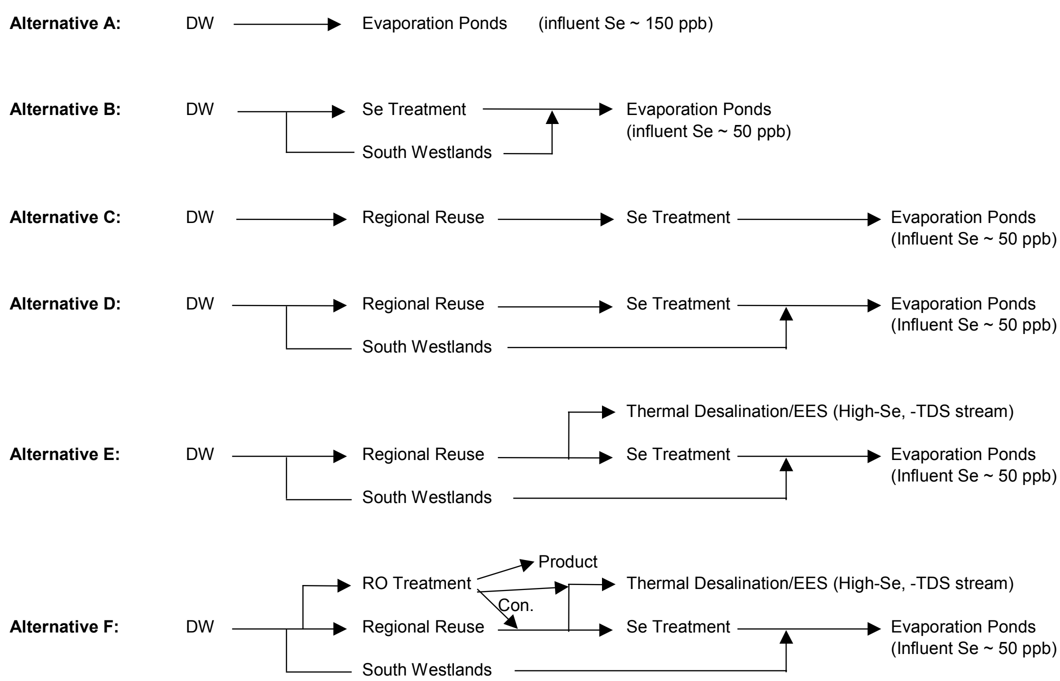


Figure 4.2-2 Schematic of Remaining In-Valley Disposal Alternatives

- **Alternative C.** Drainwater from all zones is conveyed to regional reuse facilities where it is used to irrigate salt-tolerant crops. ET within the reuse facilities reduces the drainwater volume by about 75 percent. The reused drainwater is collected in tile drains and conveyed to a biological treatment facility to reduce the concentration of Se. The initial quality of the reused drainwater is that of the perched aquifer. During the life of the project, however, the drainwater gradually becomes more concentrated. After 50 years, it is estimated that the reused drainwater will contain about 20,000 milligrams per liter (mg/L) of TDS and about 300 ppb of Se. Reused and treated drainwater is discharged to evaporation ponds for final disposal. This alternative has substantially lower treatment and evaporation costs than Alternative B because the influent volume has been reduced by 75 percent. These differences are compared to the additional cost of the regional reuse facilities: land, conveyance, irrigation systems, tile drains, and maintenance.
- **Alternative D.** Low-Se (<50 ppb) drainwater from Westlands South (about 25 percent of total drainwater) is discharged directly to evaporation ponds. Drainwater from all other zones is conveyed to regional reuse facilities, followed by biological treatment to reduce the concentration of Se, and then discharged to evaporation ponds. This alternative has lower costs for regional reuse and Se treatment but higher costs for evaporation pond disposal than Alternative C.
- **Alternative E.** Low-Se (<50 ppb) drainwater from Westlands South (about 25 percent of total drainwater) is discharged directly to evaporation ponds. Drainwater from all other zones is conveyed to regional reuse facilities. Subsequent treatment and disposal of the reused drainwater is dependent upon the TDS concentrations. Biological treatment of drainwater may not be effective or economical at TDS concentrations above 20,000 mg/L. This alternative presumes drainwater with TDS > 20,000 mg/L (i.e., Westlands North and

Central) is disposed through a combination of thermal desalination and enhanced evaporation systems (EES). Reused drainwater with TDS below 20,000 mg/L (i.e., GDA) is treated biologically and discharged to evaporation ponds. EES would be used only when ambient conditions yield evaporation rates > 90 percent so that residual liquid spray is minimized to the point that ponding does not occur. Thermal desalination would reduce the high-Se/TDS drainwater to dried salt during the periods when an EES is not used. This alternative compares the combination of thermal desalting and an EES to the combination of biological treatment with evaporation ponds in Alternative D for the disposal of high-Se/TDS drainwater.

- **Alternative F.** This alternative is identical to Alternative E except that drainwater flows are split between reuse and reverse osmosis (RO) treatment as competing methods of concentration. Reuse is estimated to reduce the volume of drainwater by about 75 percent through ET. Similarly, RO treatment could reduce the drainwater volume by as much as 75 percent. The resulting waste streams would be similar in both quantity and quality; however, RO treatment also produces high quality product water that can be reused for irrigation of salt-sensitive crops. The RO concentrate stream would be disposed by either the thermal desalting/EES combination or the biotreatment/evaporation combination depending on the TDS concentration. This alternative compares the economics of RO desalting to the economics of regional reuse as competing methods of drainwater concentration.

4.2.2 Evaluation Process Within Disposal Concept

The evaluation process for the development of the best alternative within a disposal concept was based on the following steps:

- Establishment of technical work groups for preliminary evaluation of the alternatives under the disposal concepts including the development of specific technical input (such as drainage quality and quantity, cost estimates)
- Development of comprehensive evaluation factors and screening criteria
- Application of the screening criteria to the reduced set of disposal concept alternatives described in Section 4.2.1 by the work groups and subsequent refinement by the entire Project Team at a June workshop and subsequent meetings
- Review of Project Team results by the project management group with refinement of specific components as necessary (June through August 2002)
- Final packaging of various drainwater reduction measures, treatment, conveyance, and disposal options into complete alternatives (August through September 2002)

4.2.2.1 Technical Work Groups

Seven work groups were organized to facilitate timely analysis and decision-making. Two work groups were established to develop recommendations for the best alternatives under the three disposal concepts: the Ocean and Delta Disposal Work Group and the In-Valley Disposal Work Group (Disposal Work Groups). These work groups were assisted in the development and analysis of relevant components of complete alternatives by the following work groups: Drainage Quantity and Quality, Cost Estimating, Economics, Treatment, and Evaluation Process and Criteria. An eighth work group, Public Involvement, was established in 2001 and was actively involved in the alternatives evaluation in 2002.

4.2.2.2 Comprehensive Screening Criteria and Factors

The Evaluation Process and Criteria Work Group, with input from the other technical support work groups, developed initial screening criteria for three evaluation factors or categories: cost, implementation, and potential environmental impacts. The screening criteria and the evaluation factors are outlined below.

SCREENING CRITERIA AND FACTORS

- ***Cost***
  - *Annual equivalent*
  - *Construction costs*
- ***Implementation***
  - *Time to implement*
  - *Public acceptability*
    - *Political*
    - *Public*
  - *Legal and institutional constraints (permitting process)*
  - *Flexibility to meet changing conditions*
    - *Potential future regulations*
    - *Changes in drainage quantity or quality*
- ***Environmental Impacts***
  - *Land impacts*
    - *Permanent land takes (acres)*
    - *Temporary construction impacts (acres)*
  - *Risk*
    - *Social*
    - *Environmental*

While cost and time are quantitative factors (natural scales of number of dollars and years), most of the other factors are subjective or nonquantitative and need a constructed evaluation scale. To simplify the screening process, the nonquantitative factors were ranked with numbers 1 through 5. The most positive is 5, 3 is neutral, and 1 is the most negative.

Other criteria that were considered but were ultimately not used in this phase of alternatives screening due to lack of data were Cost Effectiveness (cost per drained acre in the San Luis Unit and cost per acre-foot of drainage), Repayment Ratios (annual cost per acre-foot, and annual cost per acre), and Agricultural Productivity (total productive acres, and agricultural production value).

4.2.2.3 Results of Alternative Screening and Optimization

These criteria were incorporated into a matrix for use at a Project Team workshop in June 2002. The criteria were applied in a tiered approach: first, the prevailing factors were cost (in 2002 dollars) and time to implement, and in the second round other factors were used for these alternatives with a total cost within 30 percent of the least expensive. Each Disposal Work Group was required to make engineering and scientific judgments to complete the matrices, including use of evaluation scales (from 1 to 5) for scoring both the quantifiable and subjective criteria. The guidance/example evaluation scale for the Disposal Work Groups is included in Appendix C. The Disposal Work Groups provided one or more recommendations on the best alternative(s) within each disposal option for the entire Project Team to consider at the workshop. The completed matrices with the resulting scores are included in Appendix C. The findings of this evaluation and screening process are summarized below by type of disposal alternative:

Ocean Disposal: The Point Estero option was selected over the three Needle Point options for the following reasons:

- Time to implement was less for Point Estero, 13 years rather than 18.

- Point Estero discharge location is outside the Monterey Bay National Marine Sanctuary.
- The more southerly alignment of the Point Estero conveyance has the potential for other drainage producers to utilize the conveyance and disposal facilities.
- Point Estero had the highest average score for “other factors” (17.75 versus 11-12.75).

Delta Disposal: The Chipps Island discharge location had the lowest cost, but “other factors” scored lower. The Carquinez Strait location was kept for further analysis, even though the cost was higher, because it avoids critical Suisun Marsh habitat, avoids municipal water inlets near Antioch, and is subject to greater tidal velocities and mixing.

In-Valley Disposal: Of the six In-Valley alternatives, Alternatives A and B were eliminated based on cost and land requirements. Alternatives C, D, E, and F were kept for optimization because they met the construction cost factor threshold (30 percent from the lowest cost), had the shortest time to implement (2 to 8 years), and had the highest scores for “other factors” (19.5 to 22.25).

The results of the screening process were subject to additional review and refinement after the June workshop, and the results of this refinement are contained in Section 5 and Appendices A and C. This refinement process included the following key components:

- Development of cost curves for drainage quantity versus cost
- Update of conveyance routes and land costs
- Review of timelines for permits
- Optimization of drainwater reduction options
- Evaluation of treatment options
- Packaging of disposal with drainwater reduction, treatment, and reuse components

4.3 AGENCY AND PUBLIC OUTREACH

From the outset of the Re-evaluation process, Reclamation has sought the participation of agencies and stakeholders in the development of drainage service options and the evaluation of alternatives. Given the project’s complex history, continuing outreach was required to maintain communication and collaboration among all the critical stakeholders. Stakeholders, including the agricultural community, urban and environmental groups, coastal interests, agencies, and elected officials, have continued to provide substantive input into the alternatives evaluation.

In August 2001, Reclamation initiated the Re-evaluation effort with a one-week function analysis workshop to discuss the definition of drainage service and review potential options for providing drainage service. Reclamation published the Notice of Intent to prepare an Environmental Impact Statement (EIS) in September and conducted an agency scoping meeting in October. Two public scoping meetings were held in November 2001. Reclamation summarized the scoping comments in the PAR in December 2001.

Responding to the complex outreach needs of the Re-evaluation effort, the Public Involvement Work Group developed a coordinated, three-tiered outreach strategy that established a framework for communication and collaboration among stakeholders. The three tiers include the following:

- Decision makers and opinion leaders (e.g., elected officials in the areas designated for potential disposal locations)
- Agency staff and specialists from non-governmental stakeholder organizations
- Interested and affected individuals from the general public, including farming, fishing, community, and environmental interests

Throughout 2002, Reclamation utilized workshops, focused outreach briefings, and public meetings to share information on project development and progress and receive input. To date, Reclamation has held 15 meetings with various stakeholder interests. Table 4.3-1 lists the dates and locations of agency workshops, public meetings, and small group briefings.

These meetings generally had the following purposes and topics:

- **Agency Workshops** – Review permitting requirements, impact analysis methods and results, alternatives development and screening, evaluation criteria.
- **Opinion Leader Briefings** – Purpose and progress of Re-evaluation activities
- **Interest Group Briefings** – Purpose and progress of Re-evaluation activities, alternatives development and screening process, and impact analysis approach
- **Public Meetings** – Purpose and progress of Re-evaluation activities, alternatives development and screening process

Reclamation received significant input from stakeholders, including more than 40 written comments. Each comment was carefully considered and, in many cases, integrated into the alternatives analysis process.

Table 4.3-1
Agency Workshops, Public Meetings, and Briefings

Date	Location	Meeting
2001		
August 24	Fresno	Function Analysis Workshop
October 25	Sacramento	Interagency Workshop #1
October 30	Los Banos	San Joaquin Valley Drainage Authority
November 14 & 15	Fresno/Concord	Public Meetings
2002		
March 5	Sacramento	Interagency Workshop #2
March 6	Santa Nella	Public Workshop
March 13	Oakland	Environmental Stakeholders
March 13	Oakland	Contra Costa County Water District
March 26 and 27	Sacramento	Salinity Drainage Conference

August 26	San Luis Obispo	Area Elected Officials & San Luis Obispo County Planning Department
September 10	Sacramento	Interagency Workshop #3
September 18	Los Banos	Westside San Joaquin River Settlement Group
October 8	San Francisco	California Coastal Commission Representatives
October 8	San Francisco	Environmental Stakeholders
October 21	Fresno	Project Area Elected Officials and County Planning Administrators
November 6	Concord	Bay Area Elected Officials
December 4	Santa Nella	Public meeting

Throughout the outreach process, Reclamation developed educational materials (including a project newsletter, briefing packets, fact sheets, and meeting presentations) to make project information available to participating stakeholders and the general public at meetings, via mail, and on the project web site (www.mp.usbr.gov/sccao/sld).

In 2003, as part of the environmental documentation process, Reclamation will convene a cooperating agency group. An additional round of public scoping meetings will be conducted in the geographic areas potentially affected by the final alternatives. Small group briefings will continue their important role in exchanging information regarding the environmental impact analysis and other project activities.

SECTIONFIVE

DESCRIPTION OF ALTERNATIVES

Section 5 describes the No Action and Action Alternatives. It concludes with a summary of the cost estimates and assumptions made to develop the costs.

Under the No Action and Action Alternatives, drainage production assumes that existing CVP and local surface- and groundwater supplies would continue to be available according to existing contracts, Reclamation policy, and groundwater pumping practices. For CVP supplies, the assumption is that 59 percent of annual contract amounts would continue to be available/used on an annual average basis. In addition to the CVP supplies, some of the districts would use additional local surface- and groundwater sources of supply. The estimates do not include possible water purchases from outside the region. These supply estimates were developed for Reclamation's Westside Integrated Resources Plan (under preparation) and are shown in Table 5.1-1.

Table 5.1-1
Total Water Supplies (Acre-Feet)

District/Area	CVP Contract (100%)	Average Annual CVP Supply (59%)	Local Supplies	Average Annual Total Supply
Broadview Water District	26,980	15,920	0	15,920
Pacheco Water District	10,000	5,900	4,400	10,300
Panoche Water District	93,900	55,400	0	55,400
San Luis Water District	124,500	73,460	5,000	78,460
Westlands Water District	1,143,695	674,780	175,000	849,780
Total San Luis Unit	**1,399,075**	**825,460**	**184,400**	**1,009,860**

5.1 ALTERNATIVE 1. NO ACTION ALTERNATIVE

This section explains key assumptions for characterizing the No Action Alternative, the baseline for the analysis of environmental effects/impacts discussed later in Section 6. The No Action Alternative defines conditions in the project area through the planning time frame (2001 through 2050) if drainage service is not provided to the San Luis Unit and related areas described in Section 2.1. It represents existing conditions for drainage management in 2001 with limited changes in management reasonably expected to occur by individual farmers and districts in the absence of Federal drainage service. These changes would be "the future without the project." No Action includes only regional conveyance, treatment, or disposal facilities that existed in 2001 or authorized, funded projects.

5.1.1 Summary Description

Without Federal drainage service, farmers and districts would not be able to discharge drainwater to receiving waters (sloughs, rivers, bays, or ocean) from drainage-impaired lands except where such discharges are currently permitted (e.g., the Grassland Bypass Project). This restriction means that 260,600 acres projected to need drainage service (Table 2.2-2) would not have that service available, and farmers would pursue individual actions related to (1) drainage control and reuse and (2) cropping practices. Water districts and landowners would continue to address drainage problems within institutional, regulatory, and financial constraints currently in effect and reasonably foreseeable.

Key characteristics and assumptions for the No Action Alternative are the following facilities and land management activities.

5.1.1.1 Drainage Quantity and Quality

Drainage-impaired lands are estimated at 379,000 acres by 2050, including 298,000 acres in Westlands and 81,000 acres in the Northerly Area (see Table 2.2-1). However, much of this acreage would not be producing drainage in the absence of drainage service. Under No Action, 78,406 acres in Westlands would be retired (including 10,006 permanently retired under the Central Valley Project Improvement Act [CVPIA] program and the Britz settlement), leaving 219,594 acres needing service in Westlands and 300,594 acres in the entire study area.

No Action assumes the following management activities and facilities for drainage-impaired land:

- **On-farm/in-district use of existing drainage control/reuse measures** would continue, including 35,000 acres with drainage systems installed in the San Luis Unit (5,000 acres in Westlands and 30,000 acres in the Northerly Area) and an additional 18,000 acres outside of the San Luis Unit (the 53,000 acres total shown in Table 2.3-1). However, not all of these existing drains would be allowed to operate. Specifically, existing drains (including plugged drains) in Westlands on 5,000 acres would not be operational due to lack of drainage service. In summary, a total of 48,000 acres would continue to be drained in the GDA and none in Westlands, and no additional drains would be installed.
- **Some on-farm irrigation system improvements** would occur within Westlands to deal with perched water and crop cultural practices in the absence of drainage service from Reclamation, but no new tile drains would be installed. Westlands would continue efforts to develop tilewater treatment and disposal technologies. However, consistent with the definition of No Action to exclude unplanned or speculative projects, it is assumed that no new on-farm tile systems, collection facilities, or land disposal actions would be constructed. Limited use of existing facilities for on-farm drainwater recycling would occur.
- **Irrigation practices** begin at current efficiency levels. As the drainage problem expands and farmers adjust irrigation practices to high water table conditions, water use efficiency in these areas may increase.[1] Overall, irrigation practices would be expected to respond to economic conditions and would be consistent with efficiency assumptions in the *California Water Plan* (DWR 1993). See Appendix G, Section G6 for a discussion of these economic conditions and anticipated changes in agricultural practices.
- **Any water freed up from fallowing in drainage-impacted areas would be reallocated to unaffected areas**. Water conserved because of improved irrigation efficiency, changes in cropping pattern, increased contribution to ET from groundwater, or possible reductions in irrigated acreage would be available within the respective district to meet internal needs. The

[1] The groundwater modeling at this stage in the analysis does not assume any reduction in deep percolation from improved irrigation systems.

reallocated water would likely result in less groundwater pumping, as the quantity applied per acre would not increase beyond crop requirements.

- **Other drainwater reduction measures** are anticipated to be used at current levels under No Action with no drainage outlet. These measures are seepage reduction, drainwater recycling, shallow groundwater pumping, on-farm irrigation system improvements, and shallow drainage. These measures are defined in Section 3.2.1. New pumping and/or improvements not currently funded would not be included in No Action.
- Part of the GDA's planned In-Valley Treatment/Drainage Reuse Facility would be included under No Action, specifically those components that are currently constructed, designed, and funded.
  - The constructed and funded components include 4,000 acres of land for planting with salt-tolerant crops. Twenty-two hundred acres have been planted, with another 500 acres in the process of being planted, and subsurface drainage systems have been installed on a total of 900 planted acres (an additional 300 acres have subsurface drainage but are not planted).
  - Without additional funding, the remainder of the 4,000 acres could not be planted, and no additional subsurface drainage systems would be installed.
  - In its current condition 7,200 AF of salty drainwater can be displaced through the facility (8,100 AF applied, 900 AF discharged).
- Under the current Use Agreement, expiring December 31, 2009, the Grassland Area Farmers must meet their load requirements within 20 percent of the target. The exceedance triggers a fine. If the target is exceeded by more than 20 percent, the Use Agreement can be terminated and thereby no discharges allowed.

5.1.1.2 Biotreatment

The remaining components of the GDA's In-Valley Treatment/Drainage Reuse Facility are not included under No Action because of the uncertainties associated with their design, operation, and funding. These remaining components include additional land acquisition (2,000 acres), additional subsurface drainage systems (for 4,800 acres), and the treatment facility/disposal units. Designs may not be completed until 2006, and the facility is planned to be operational by 2009 if funding can be obtained.

It is assumed that the Grassland Area Farmers would participate in whatever action alternative is selected as the proposed action, consistent with their *Long-Term Drainage Management Plan for the Grassland Drainage Area* (Grassland Area Farmers and Delta-Mendota Water Authority 1998), as long as they can meet their Waste Discharge Requirements (WDRs) in 2009. Therefore, the not yet funded parts of the GDA facilities are included as a component in the In-Valley Disposal Alternative (Section 5.5).

No other facilities beyond small-scale pilot projects and existing reuse facilities (e.g., Integrated Farm Drainage Management projects such as Red Rock Ranch) are assumed to be operational in the study area under No Action.

5.1.1.3 Conveyance

The San Luis Drain would not be used to convey drainage except for the northern San Luis Unit districts that are part of the GDA. These districts have use of 28 miles of the existing Drain from October 2001 through December 2009. The No Action Alternative assumes no use of the Drain beyond 2009. In-district or on-farm management of drainwater by districts and/or farmers would rely on existing canals and waterways and budgeted improvements to those systems.

5.1.1.4 Land Requirements

Irrigated Acreage

No new lands would be brought into irrigated production with one exception. Westlands acquired 15,000 acres in 1999 that have been dry-farmed since 2000, but are assumed to be available for irrigated agriculture.

Land Retirement

Land retirement is defined as the removal of lands from irrigated agricultural production by purchase or lease for other purposes or land uses. Under No Action, Reclamation assumes implementation of land retirement of 78,406 acres based on the following:

1. CVPIA Land Retirement – Up to 7,000 acres of lands are included to be retired within the study area under the existing CVPIA land retirement program (2,091 acres retired to date). These retired lands are assumed for all alternatives.
2. Westlands Settlement Agreement (*Sagouspe v. Westlands Water District*) – A settlement agreement among various classes of water users within Westlands calls for temporary retirement of land. An estimated 68,400 acres of land would be retired under this settlement agreement. Because the agreement would allow these lands to come back into production if and when Reclamation provides drainage service, Reclamation assumed these lands would be retired only under the No Action Alternative.
3. Britz Settlement (*Sumner Peck Ranch, Inc., et al. v. Bureau of Reclamation, et al.*) – An additional 3,006 acres in Westlands are being retired permanently under a settlement agreement dated September 3, 2002, between the United States, Westlands, and the Britz group of plaintiffs in the Sumner Peck lawsuit. These retired lands are assumed for all alternatives.

This acreage does not include annual land fallowing. The Westlands acreage of 68,400 acres is to be retired from irrigated agricultural production until Reclamation makes available drainage service, so this estimate applies only to No Action. In summary, 10,006 acres of permanent retirement would be increased by 68,400 acres if drainage service is not provided to Westlands.

Land Fallowing

On an annual basis, 5 to 10 percent of the total land acreage is often fallowed for agronomic purposes, and this practice would continue under No Action.

5.1.2 Implementation Schedule and Costs

No new facilities, other than those currently approved and funded as components of the Grassland Bypass Project, are to be completed by 2050.

The costs of No Action include the net increase in irrigation and salinity management costs, revenue losses from growing a salinity-restricted crop mix, and revenue losses associated with lands out of production. These costs are described in Appendix G6 and will be further evaluated as part of the impact analysis in the EIS.

5.2 COMMON ELEMENTS TO ALL ACTION ALTERNATIVES

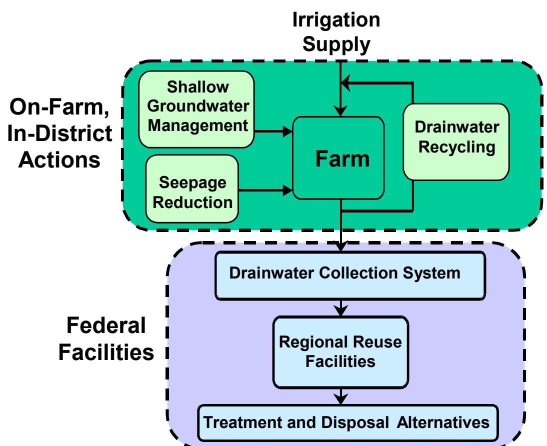


Figure 5.2-1 Common Elements to All Disposal Alternatives

The quantity of drainwater requiring treatment and/or disposal can be reduced by implementation of drainwater reduction measures. As discussed in Section 3, several considerations go into estimating the design drainwater quantity and quality for each disposal alternative. Section 3 also evaluated the cost effectiveness of several drainwater reduction options. Results of this analysis yielded the reasonable drainwater reduction actions that could be implemented within the drainage area and that are common to all disposal alternatives. These drainwater reduction actions are shown on Figure 5.2-1 and are briefly described below. A more detailed description of each of these actions is included in Section 3.

On-farm, in-district actions include:

1. **Drainwater Recycling.** Blending of drainage water, either at the farm or district level, with freshwater supplies up to a salinity level that is still acceptable for use on commercial crops.
2. **Shallow Groundwater Management.** Managing groundwater levels in tile drainage systems to partially utilize the shallow groundwater to meet crop needs.
3. **Seepage Reduction.** Lining or piping of existing unlined irrigation conveyance and distribution facilities to reduce seepage losses into the groundwater. This option tends to reduce recharge to the shallow aquifer, thereby reducing the quantity and/or postponing the need for artificial drainage.

The on-farm, in-district drainwater reduction actions are not components of the drainage service alternatives to be implemented by Reclamation. Rather they represent the estimates Reclamation has made regarding the conditions of the area to be served and the reasonable actions that could be implemented by districts within the area to estimate a reasonable drainage quantity and quality for the future once drainage service is provided. Although drainwater reduction actions other than the ones selected could be implemented to reduce drainage flows, it was determined that they were either not cost effective compared to the disposal facilities, or it was not reasonable to assume that they would be implemented due to the uncertainty regarding the effectiveness of the action. Farmers would install subsurface tile drains on drainage-impaired lands.

As part of the Federal action, Reclamation would construct a closed **collection system** to collect and convey drainwater from on-farm subsurface tile drains to the **regional reuse facilities** located within each of the four zones (Northerly Area, Westlands North, Westlands Central, and Westlands South). The drainwater would be used to irrigate salt-tolerant crops at the reuse facilities. The reuse facility would also serve as an underground regulating reservoir to control the flow of reused drainwater to downstream features. At the reuse facilities, subsurface tile drains would be installed to collect the reused drainwater. The reused drainwater would be conveyed via pipeline or canal to treatment and/or disposal facilities. The water quality of the reused drainwater would be the same as the water quality of the perched aquifer beneath the reuse facility. It is expected that water quality of the perched aquifer would gradually decline during long-term use as do all aquifers underlying irrigated farmlands.

The drainage rate after drainwater reduction measures is about 29,400 AF/yr for the Out-of-Valley Disposal Alternatives (41 cfs maximum flow rate) and 28,800 AF/yr for the In-Valley Disposal Alternative (40 cfs maximum flow rate). After drainwater reduction, the quality of the drainwater is expected to be about 17,200 mg/L of TDS and 361 micrograms per liter (µg/L) of Se.

The following sections (5.3, 5.4, and 5.5) describe the action alternatives.

5.3 ALTERNATIVE 2. OCEAN DISPOSAL ALTERNATIVE

5.3.1 Summary Description

The Ocean Disposal Alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be collected from the regional reuse facilities and transported by pipeline to the Pacific Ocean for disposal. The pipeline conveyance system, would lie within the San Joaquin Valley from near Los Banos southeast to just south of Kettleman City, and then extend southwesterly to the Pacific Ocean at Point Estero. The ocean diffuser would be approximately 1.44 miles offshore, at a depth of 200 feet, approximately 10 miles south of the southern boundary of the Monterey Bay National Marine Sanctuary. Figure 5.3-1 shows the key components of this alternative.

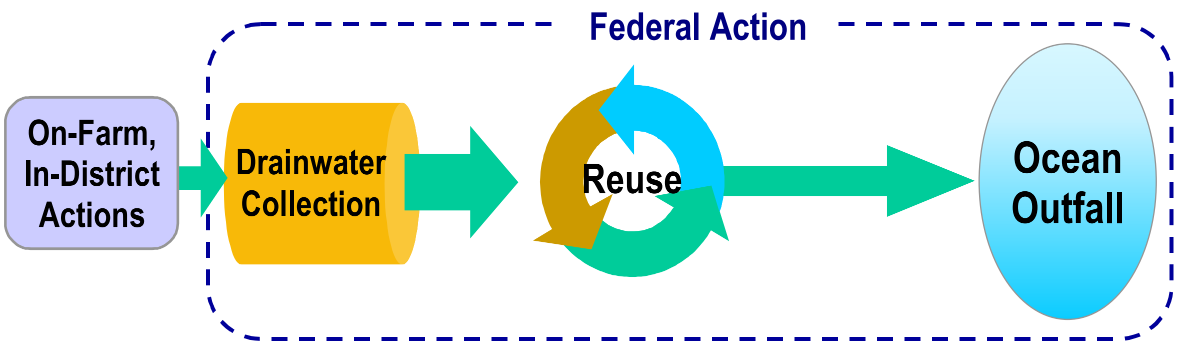


Figure 5.3-1 Components of the Ocean Disposal Alternative

The key components of this alternative are:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to the ocean outfall.

Figure 5.3-2 shows the general location of this alternative, and Table 5.3-1 summarizes the key features and specifications. The topographic route and the principal components of the drainage aqueduct are included in Appendix D, Conveyance Alignments, Structures, and Facilities.

The drainwater aqueduct for the Ocean Disposal Alternative would include 177 miles of buried pipeline, with three tunnels through the coastal range and ten pumping plants. To the extent possible, existing ROWs and conveyance facilities would be used. The aqueduct would have only one diffuser, located 1.44 miles off Point Estero.

The aqueduct would collect drainwater at four locations near the existing San Luis Drain. The most northern intercept would be located south of Dos Palos. The aqueduct would proceed southerly to a point 10 miles south of Kettleman City, where it would head west to Point Estero. The aqueduct would proceed through and over the Coast Ranges and discharge into the ocean.

About 174.8 miles of 42-inch-diameter or less polyvinyl chloride (PVC) pipe or similar would be installed. About 2.1 miles of 7-foot-diameter tunnel would be excavated and a 1.1-mile-long siphon would be constructed. An additional 1.44 miles of high-density polyethylene (HDPE) pipeline would be installed either buried or suspended under water along the ocean floor.

The drainwater from the reuse facilities would have properties different from those of normal irrigation water. These different properties would influence the hydraulics by changing the friction factors in only a minor way and increase the pumping head required to lift the water from one elevation to another. The hydraulic properties to use in this design would be kinematic viscosity = $1.06 \times 10\text{-}5$ ft^2/s and a unit weight of 63.1 pounds per cubic foot.

Table 5.3-1
Summary of Features and Specifications, Ocean Disposal Alternative (2050)

Component	Characteristic	
Drainage Area	Acres with tile drains installed by 2050	241,700
On-Farm Drainwater Reduction	Volume reduced by improved irrigation per year (AF)	0
	Volume reduced by shallow-water management per year (AF)	4,800
Regional Drainwater Reduction	Volume reduced by seepage reduction per year (AF)	4,200
	Volume reduced by shallow groundwater pumping per year (AF)	0
Other Drainwater Reduction	Volume reduced by recycling per year (AF)	23,800
	Acres of land fallowing	0
Drainage Rate After Drainwater Reduction	Drainage volume per year (AF)	108,900
Drainage Reuse	Volume reduction in Northerly Area per year (AF)	25,700
	Volume reduction in Westlands North per year (AF)	18,700
	Volume reduction in Westlands Central per year (AF)	18,700
	Volume reduction in Westlands South per year (AF)	16,500
Drainage Rate After Reuse	Drainage flow rate in AF/acre/year (average)	29,400
	Drainage flow rate in cfs (average)	41
Treatment	Average Se concentration of reused drainwater (µg/L)	361
	Volume to Se biological treatment per year (AF)	NA
	Volume to RO treatment per year (AF)	NA
	Volume to TD/EES treatment per year (AF)	NA
	Average Se concentration at point of discharge (µg/l)	361
Land Conveyance	Miles of pipe	174.8
	Miles of tunnel	2.1
Under Water Conveyance	Miles of tunnel pipe under water	0
	Miles of suspended pipe under water	0.71
	Miles of buried pipe under water	0.73
Total Conveyance	Total miles of conveyance	178.3
Energy Use/Generation	Energy requirements for conveyance (kw-hr/year)	110,000,000
	Energy requirements for treatment (kw-hr/year)	NA
	Energy generated (kw-hr/year)	0
Land Requirements	Acres of reuse	27,200
	Acres of Se treatment facility (lagoon/high rate)	NA
	Acres of evaporation ponds	NA
	Acres of temporary right-of-way[1]	1,700
	Acres of permanent right-of-way (conveyance, tunnel portals, and pumping plants)[2]	670
	Acres of required mitigation	TBD
Biology	Acres of sensitive habitat impacted	55
Drainwater Reclamation	Volume of water reclaimed per year (product water) (AF)	NA
	Tons of salt generated for reuse	NA

Notes:
[1] Includes temporary right-of-way for 10 pumping plants (30 acres) and pipeline (75 feet wide) .
[2] Includes permanent right-of-way for 3 tunnels/6 tunnel portals (60 acres), 10 pumping plants (20 acres), and pipeline (30 feet wide).

NA = not applicable to this Disposal Alternative.
TBD = to be determined in future detailed analysis.

Figure 5.3-2 Ocean Disposal Alternative

Based on an initial appraisal-level reconnaissance of the Ocean Disposal Alternative proposed pipeline alignments and facility locations, construction-related impacts would be effectively controlled through implementation of impact avoidance measures and post-construction site restoration commitments. In most cases, construction impacts would be of short duration. At present, no specific impacts have been identified that require acquisition and development of replacement habitat to offset significant unavoidable habitat damage or degradation. However, additional impacts possibly requiring yet-to-be-determined mitigation measures may still be identified when the EIS is prepared, detailed engineering specifications are finalized, and future detailed biological surveys are completed.

Identification of the potential facility locations and conveyance alignments was based on a variety of existing information that indicates they may be suitable for their intended purposes. Final selection of conveyance and facility locations will require additional field investigations and data analysis to evaluate a variety of engineering and environmental parameters (e.g., soils, groundwater, land use, and endangered and protected species).

5.3.2 Implementation Schedule and Costs

A preliminary implementation schedule was developed for the Ocean Disposal Alternative (Figure 5.3-3). Factors used in developing the schedule include permitting, engineering design, land acquisition, and construction. The schedule assumes that land acquisition and engineering design would occur concurrent with permitting activities. Construction activities include the drainage collection system, drainage reduction measures, reuse facilities, and conveyance.

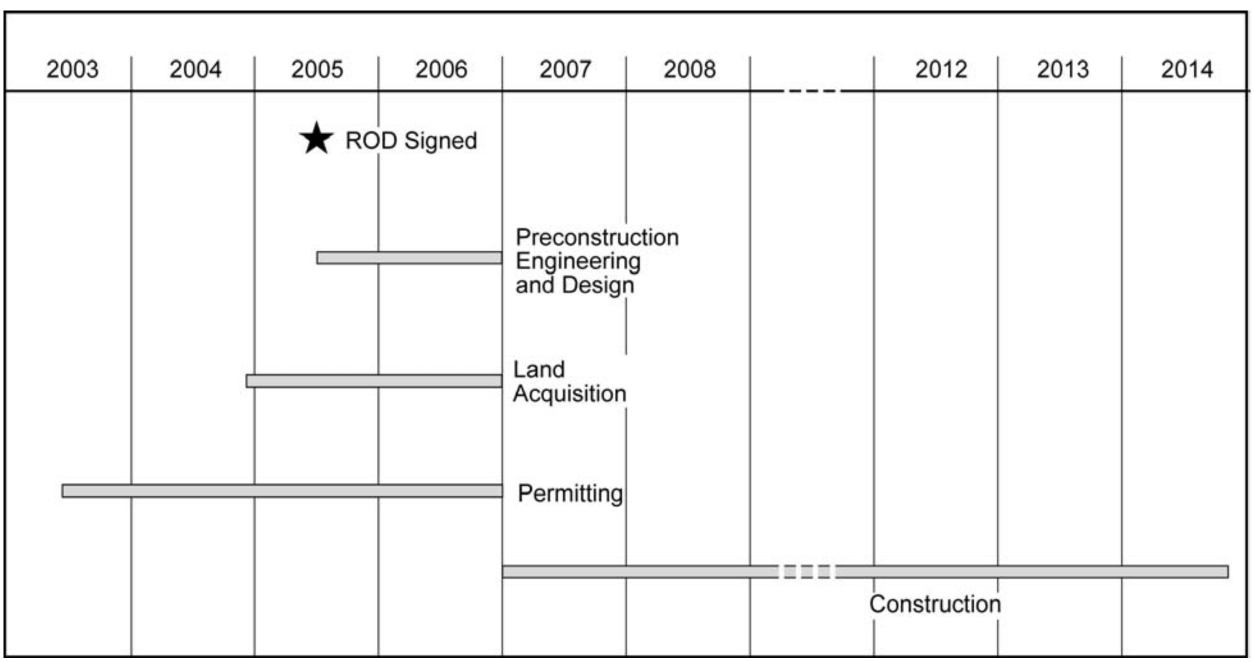


Figure 5.3-3 Ocean Disposal Alternative Implementation Schedule

The summary of the estimated present value and annual equivalent costs for the Ocean Disposal Alternative at 41 cfs is included in Table 5.3-2. The assumptions for development of these cost estimates are discussed in Section 5.6.

Table 5.3-2
Ocean Disposal Alternative, Present Worth of Total Project Costs

Project Features	Present Value ($1,000)	Annual Equivalent ($1,000)
FEDERAL PROJECT COSTS		
Federal Costs - Alternative Specific		
Conveyance System	600,954	37,463
Evaporation Ponds	0	0
Evaporation Pond Mitigation Facilities	0	0
Reverse Osmosis Facilities	0	0
Biological Selenium Treatment	0	0
Subtotal - Alternative Specific Federal Costs	600,954	37,463
Common Federal Costs		
Drainage Collection System	362,929	22,625
Regional Reuse Facilities	48,765	3,040
Subtotal - Common Federal Costs	411,693	25,665
SUBTOTAL - FEDERAL PROJECT COSTS	**1,012,647**	**63,128**
NONFEDERAL PROJECT COSTS		
Drainwater Reduction Measures		
Drainwater Recycling	19,726	1,230
Seepage Reduction	8,091	504
Shallow Groundwater Management	16,151	1,007
Subtotal - Drainwater Reduction	43,968	2,741
On-Farm Tile Drainage System	126,099	7,861
SUBTOTAL - NONFEDERAL PROJECT COSTS	**170,067**	**10,602**
TOTAL PROJECT COSTS	**1,182,714**	**73,730**

5.4 ALTERNATIVE 3. DELTA DISPOSAL ALTERNATIVES

5.4.1 Alternative 3a. Delta-Chipps Island Disposal Alternative

5.4.1.1 Summary Description

The Delta-Chipps Island Disposal Alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be treated with biological Se treatment before conveyance by canal and pipeline to the Sacramento-San Joaquin River Delta (Delta) for disposal. The canal and pipeline conveyance system would extend the existing San Luis Drain from its current terminal at Mud Slough to the north-northwest through Merced, Stanislaus, San Joaquin, and Contra Costa Counties for disposal at the western end of the Delta at Chipps Island. The diffuser would be approximately 1 mile from the shoreline at Mallard Slough at a depth of 18 feet. Figure 5.4-1 shows the key components of this alternative.

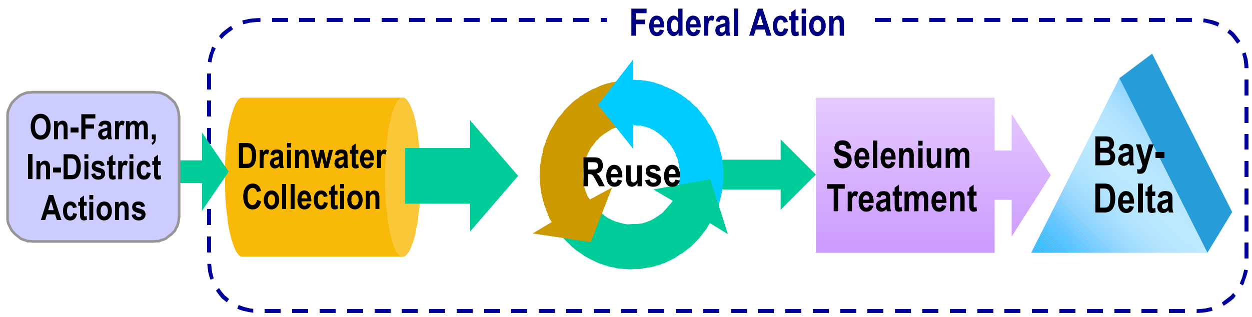


Figure 5.4-1 Components of the Delta Disposal Alternative

The key components of this alternative are:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to treatment facilities.

Selenium Biotreatment –Drainwater from the regional reuse facilities would be treated to remove Se and reduce the environmental impacts to the Delta. Treatment would consist of the biological removal of selenium in aerated lagoons. To prevent seepage into local groundwater supplies, each lagoon would consist of a concrete bottom with a secondary plastic liner. Floating covers on the lagoons would prevent oxygen interference with the process, reduce operating costs, and prevent wildlife access to the lagoon water. Selenium treatment produces a small amount of sludge (holding the concentrated selenium) that would be transported offsite for disposal as a hazardous material. Based on past studies showing selenium removal rates of 68 to 92 percent, Reclamation used an 80 percent removal rate for planning purposes.

Figure 5.4-2 presents the general location of this alternative, and Table 5.4-1 summarizes the key features and specifications. The topographic route and the principal components of the drainage aqueduct are included in Appendix D.

The drainwater aqueduct for the Delta-Chipps Island Disposal Alternative would traverse gradually sloping to flat lands. A total of about 107.6 miles of pipeline and canal would be installed, including 1 mile of buried pipe underwater. In addition, about 83 miles of the existing San Luis Drain would be used, for a total conveyance length of 190.6 miles.

Relatively inexpensive canals and buried low-head pipelines would be used for conveyance in agricultural and sparsely populated areas. In the vicinity and through urban and rapid growth areas, the conveyance would be by pipelines. In two uphill areas, the flow would be in high-pressure pipelines from two pumping plants. One pumping plant would be located near the junction of Linne and Kasson Roads, northwest of San Joaquin River Club. The second pumping plant, located northeast of Brentwood, would deliver flow uphill toward Contra Loma Regional

Table 5.4-1
Summary of Features and Specifications, Delta-Chipps Island Disposal Alternative (2050)

Component	Characteristic	
Drainage Area	Acres with tile drains installed by 2050	241,700
On-Farm Drainwater Reduction	Volume reduced by improved irrigation per year (AF)	0
	Volume reduced by shallow-water management per year (AF)	4,800
Regional Drainwater Reduction	Volume reduced by seepage reduction per year (AF)	4,200
	Volume reduced by shallow groundwater pumping per year (AF)	0
Other Drainwater Reduction	Volume reduced by recycling per year (AF)	23,800
	Acres of land fallowing	0
Drainage Rate Drainwater Reduction	Drainage volume per year (AF)	108,900
Drainage Reuse	Volume reduction in Northerly Area per year (AF)	25,700
	Volume reduction in Westlands North per year (AF)	18,700
	Volume reduction in Westlands Central per year (AF)	18,700
	Volume reduction in Westlands South per year (AF)	16,500
Drainage Rate After Reuse	Drainage volume in AF/acre/per year (average)	29,400
	Drainage flow rate in cfs (average)	41
Treatment	Average Se concentration of reused drainwater (µg/L)	361
	Volume to Se biological treatment per year (AF)	29,400
	Volume to RO treatment per year (AF)	0
	Volume to TD/EES treatment per year (AF)	0
	Average Se concentration at point of discharge (µg/l)	72
Land Conveyance	Miles of pipe	46.5
	Miles of new canal	60.1
	Miles of existing canal	83
Under Water Conveyance	Miles of tunnel pipe under water	0
	Miles of suspended pipe under water	0
	Miles of buried pipe under water	1
Total Conveyance	Total miles of conveyance	190.6
Energy Use/Generation	Energy requirements for conveyance (kw-hr/year)	17,150,000
	Energy requirements for lagoon treatment (kw-hr/year)	2,506,000
	Energy generated (kw-hr/year)	NA
Land Requirements	Acres of reuse	27,200
	Acres of Se treatment facility (flow 41*1.2)	160
	Acres of evaporation ponds	NA
	Acres of temporary right-of-way[1]	1,000
	Acres of permanent right-of-way (pipeline)[2]	180
	Right-of-way (canal)[2]	560
	Acres of required mitigation	TBD
Biology	Acres of sensitive habitat impacted	73
Drainwater Reclamation	Volume of water reclaimed per year (product water) (AF)	NA
	Tons of salt generated for reuse	NA

Notes:
[1] Includes temporary right-of-way for 2 pumping plants and regulating tanks (8 acres), pipeline (75 feet wide), and canal (100 feet wide) .
[2] Includes permanent right-of-way for 2 pumping plants and regulating tanks (6 acres), pipeline (30 feet wide), and canal (100 feet wide).

NA = not applicable to this Disposal Alternative.
TBD = to be determined in future detailed analysis.

Figure 5.4-2 Delta Disposal Alternatives

Park south of Antioch. Most of the pipeline alignment would follow existing highways, canals, and railroad tracks.

Canals would be designed with a 4-foot-wide bottom, a side slope of 2:1, and concrete lining. Pipelines would be designed with a 36-inch-diameter pipe for high-pressure lines and 60-inch-diameter pipe for low-head lines. Rugosity or roughness would be equal to 0.00001. Approximately 10 miles of the high-pressure pipeline in urban areas, such as Pittsburg, would be constructed within narrow railroad ROWs that would reduce the efficiency of pipeline installation.

Based on an initial appraisal-level reconnaissance of the Delta-Chipps Island Disposal Alternative proposed pipeline alignments and facility locations, construction-related impacts would be effectively controlled through implementation of impact avoidance measures and post-construction site restoration commitments. In most cases, construction impacts would be of short duration. At present, no specific impacts have been identified that require acquisition and development of replacement habitat to offset significant unavoidable habitat damage or degradation. However, additional impacts possibly requiring yet-to-be-determined mitigation measures may still be identified when the EIS is prepared, detailed engineering specifications are finalized, and future detailed biological surveys are completed.

Final selection of conveyance and facility locations would require additional field investigations and data analysis to evaluate a variety of engineering and environmental parameters (e.g., soils, groundwater, land use, and endangered and protected species). Identification of the potential locations was based on a variety of existing information that indicates they may be suitable for their intended purposes.

The reused drainwater would be treated for Se removal to reduce the effluent concentration at the Delta-Chipps Island discharge. As described in Section 3, the combined effluent flow rate from the reuse facilities and, therefore, the design flow rate for the treatment facility is 41 cfs. However, for costing and sizing of the treatment facility, a flow of 49.2 cfs (41 cfs × 1.2 variability factor) was assumed to account for the redundancy of the treatment components required for maintenance and/or temporary shutdown. The reused drainwater characteristics are also described in Section 3. The flow-weighed average Se and TDS concentrations after several years of reuse facility operation are 361 μg/L and 17,200 mg/L, respectively.

Treatment would consist of biological removal of Se. Biological removal uses bacteria to create anoxic conditions which convert selenate to elemental Se and other reduced (likely organic) species. Elemental Se has a low solubility and can be separated from solution using standard settling/clarification and filtration methods. Organic Se species are more soluble than elemental Se and more difficult to separate. In addition to Se removal the biotreatment system would remove nitrate and constituents that are associated with particulates (such as some metals) in the treatment system. If nitrate is present, it can be an interfering substance. Bacterial reduction of nitrate is similar to bacterial reduction of selenate, although different bacterial species may be involved. Nitrate is preferentially reduced before selenium owing to the energetics of the reduction reaction. For this reason nitrate must often be removed before selenium reduction will occur in earnest. Most Se removal occurs in the region between the practical definition of anoxic and anaerobic conditions. Anoxic conditions can be created readily by adding a carbonaceous source to stimulate the growth of naturally occurring bacteria that will reduce nitrate to nitrogen gas. Past pilot studies have shown that the rates of removal of Se with lagoon type biological treatment followed by clarification ranged from 68 to 92 percent during a 4-year study (Quinn et al. 2000). For this current planning document, an 80 percent removal rate was used.

Two types of biotreatment were evaluated: lagoon treatment and high rate treatment. Detailed information on each of these treatment processes is included in Appendix E. Based on available cost information, lagoon treatment was selected. The removal of selenium by biological systems has been known for decades; however, researchers are attempting to define the biological removal mechanism and the environmental conditions needed for optimum performance. Since all of the factors affecting biological selenium removal have not been fully defined, some of the following discussion is based on best professional judgment and would be confirmed during the future design of the system. Furthermore, reused drainwater concentrations of Se and TDS are likely to increase over time. Treatment efficiency would be evaluated over time, and changes may be incorporated into the design to optimize the treatment process.

A schematic of the lagoon treatment facility is shown on Figure 5.4-3. The site is assumed to be suitable for gravity flow through the treatment facility. The facility consists of an influent equalization basin, five anoxic lagoon cells in series, an aerated lagoon, a filtration system, and feed tanks and pumps. The anoxic lagoons are sized with a 20-foot liquid depth to minimize surface area and would be covered by a floating cover to minimize the effects of wind-induced aeration. The pilot tests have been run using molasses as the carbon source. This supplemental organic carbon is one of the major operating costs. For the purposes of this evaluation, methanol was assumed to be used as the carbon source. Other organic materials could be used in place of methanol such as sugar, molasses, and other food processing wastes.

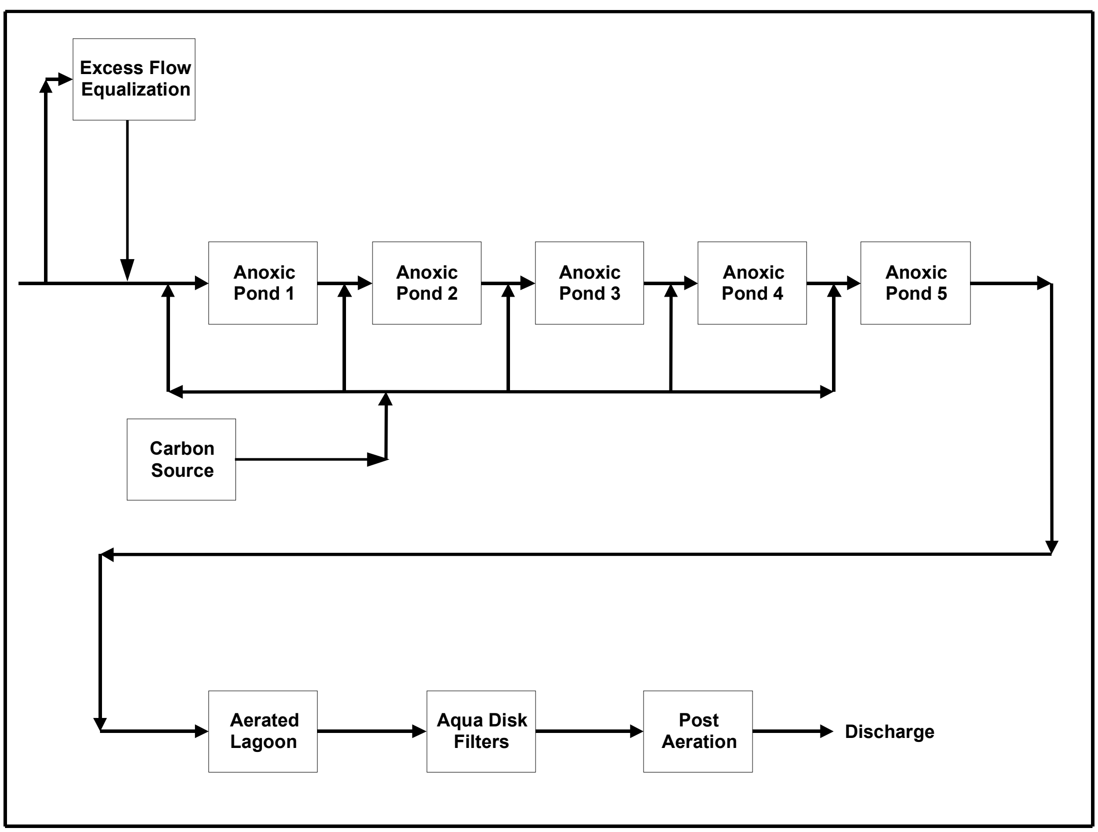


Figure 5.4-3 Lagoon Biological Selenium Removal Process Flow Schematic

5.4.1.2 Implementation Schedule and Costs

A preliminary implementation schedule was developed for both the Delta Disposal Alternatives (Figure 5.4-4). Factors used in developing the schedule included permitting, engineering design, land acquisition, and construction. The schedule assumes that land acquisition and engineering design would occur concurrent with permitting activities. Construction activities include the drainage collection system, drainage reduction measures, reuse facilities, Se biotreatment plants, and conveyance.

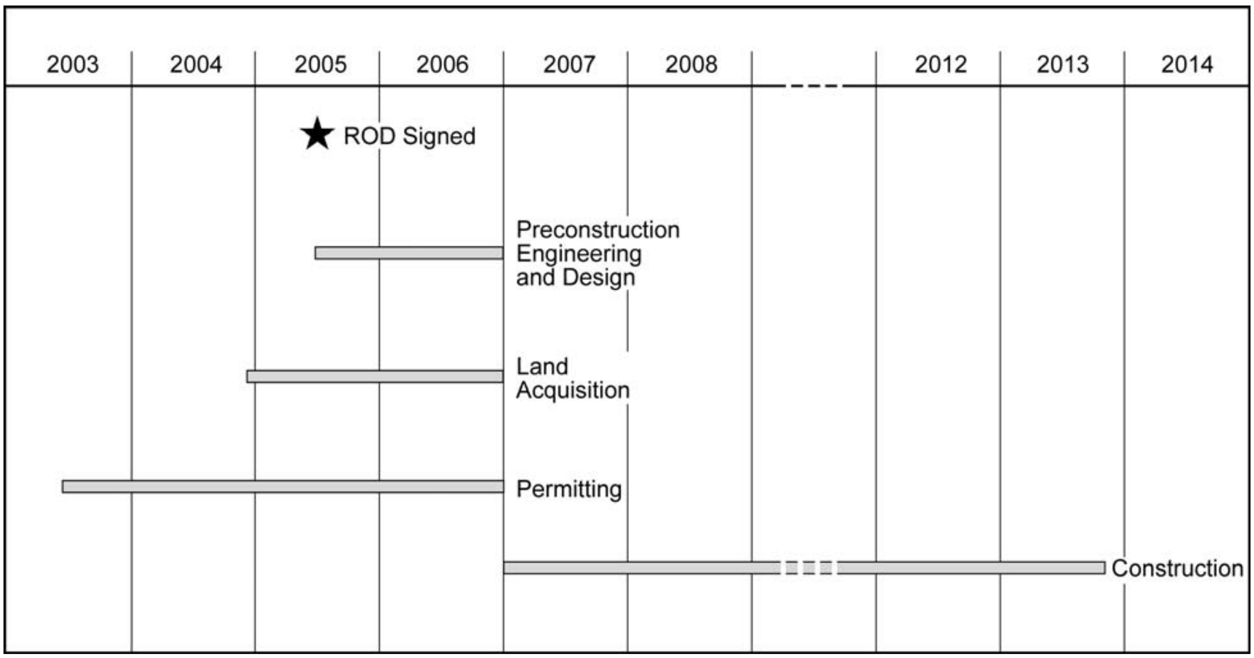


Figure 5.4-4 Delta Disposal Alternative Implementation Schedule

The summary of the estimated present value and annual equivalent costs for the Delta-Chipps Island Disposal Alternative at 41 cfs is included in Table 5.4-2.

Table 5.4-2
Delta-Chipps Island Disposal Alternative,
Present Worth of Total Project Costs

Project Features	Present Value ($1,000)	Annual Equivalent ($1,000)
FEDERAL PROJECT COSTS		
Federal Costs - Alternative Specific		
Conveyance System	289,512	18,048
Evaporation Ponds	0	0
Evaporation Pond Mitigation Facilities	0	0
Reverse Osmosis Facilities	0	0
Biological Selenium Treatment	135,180	8,427
Subtotal - Alternative Specific Federal Costs	424,691	26,475
Common Federal Costs		
Drainage Collection System	362,929	22,625
Regional Reuse Facilities	48,765	3,040
Subtotal - Common Federal Costs	411,693	25,665
SUBTOTAL - FEDERAL PROJECT COSTS	**836,385**	**52,140**
NONFEDERAL PROJECT COSTS		
Drainwater Reduction Measures		
Drainwater Recycling	19,726	1,230
Seepage Reduction	8,091	504
Shallow Groundwater Management	16,151	1,007
Subtotal - Drainwater Reduction	43,968	2,741
On-Farm Tile Drainage System	126,099	7,861
SUBTOTAL - NONFEDERAL PROJECT COSTS	**170,067**	**10,602**
TOTAL PROJECT COSTS	**1,006,452**	**62,742**

The following considerations were incorporated into the design and cost estimates.

- **Influent water quality.** Influent water quality was estimated based on best available data and professional judgement. The effect of reuse facilities on nitrate, Se, and TDS concentrations in drainwater was estimated based on best professional judgment since long-term monitoring data from such facilities do not exist. This is particularly important because biotreatment system operating costs are largely a function of influent nitrate concentration, which was estimated to be 53 mg/L Nitrate as N. To account for these uncertainties inherent in the design assumptions, the contingency factor for developing the costs was increased to 65 percent.
- **Double Containment for Waste Handling.** The biological sludge will have a high Se content and it was assumed to be classified and disposed of as hazardous waste. To accommodate this each anoxic lagoon was designed with dual containment consisting of a concrete slab underlined with a HDPE liner. Alternative configurations may be investigated during future design.
- **Floating Covers for Biological Oxygen Demand Control.** To prevent oxygen interference with the process and to reduce operating costs, the lagoons were designed with floating covers. The floating covers also would have another benefit in that enclosure netting, hazing programs, and additional mitigation ponds would not be required because the lagoon water surface would not be accessible to wildlife. Costs for odor control were not included.

Section 5.6 further discusses the assumptions used in these cost estimates.

5.4.2 Alternative 3b. Delta-Carquinez Strait Disposal Alternative

5.4.2.1 Summary Description

This alternative has the same route and design elements as the Delta-Chipps Island Disposal Alternative, except that it continues west past Martinez to Carquinez Strait for disposal immediately upstream of Carquinez Bridge. Tidal flows heavily influence the mixing of the water in this area. Figure 5.4-1 shows the key components of this alternative and Figure 5.4-2 presents the general location of this alternative. Table 5.4-3 summarizes key features and specifications. The topographic route and the principal components of the drainage aqueduct are included in Appendix D.

A total of about 125 miles of pipeline and canal would be installed, including 1 mile of pipe buried underwater. In addition, about 83 miles of the existing San Luis Drain would be used, for a total conveyance length of 208 miles. The Delta-Carquinez Strait route follows the Delta-Chipps Island route, but continues west along the railroad tracks past Martinez to Carquinez Strait Regional Shoreline to the city of Crockett, where it goes offshore to the diffuser. The diffuser would be approximately 16 miles downstream of the western end of the Delta and 1 mile from the shoreline at Crockett at a depth of 18 feet. Approximately 20 miles of pipeline would be installed within the narrow railroad ROWs in urban areas, such as Pittsburg, and along the railroad tracks on shoreline from Mallard Slough to Carquinez Strait. The limited ROW can be expected to reduce the efficiency of pipeline installation. This disposal location has greater tidal action and is further removed from drinking water intakes than the Delta-Chipps Island Alternative.

5.4.2.2 Implementation Schedule and Costs

The time to implement this alternative is the same as for the Delta-Chipps Island Disposal Alternative (see Section 5.4.1.2 and Figure 5.4-4). Drainage service would begin in October 2013.

The summary of the estimated present value and annual equivalent costs for the Delta-Carquinez Strait Disposal Alternative at 41 cfs is included in Table 5.4-4. The same design considerations and assumptions identified for the Delta-Chipps Island Disposal Alternative apply to this alternative.

5.5 ALTERNATIVE 4. IN-VALLEY DISPOSAL ALTERNATIVE

5.5.1 Summary Description

The In-Valley Disposal Alternative would lie within the San Joaquin Valley and entirely within the boundaries of the drainage study area. This alternative would include the common elements of all alternatives: on-farm and in-district actions, drainwater collection systems, and regional reuse facilities. Reuse drainwater would be treated with reverse osmosis and biological selenium treatment before disposal in evaporation ponds. Figure 5.5-1 illustrates the key components of the In-Valley Disposal Alternative.

Table 5.4-3
Summary of Features and Specifications, Delta-Carquinez Strait Disposal Alternative (2050)

Component	Characteristic	
Drainage Area	Acres with tile drains installed by 2050	241,700
On-Farm Drainwater Reduction	Volume reduced by improved irrigation per year (AF)	0
	Volume reduced by shallow-water management per year (AF)	4,800
Regional Drainwater Reduction	Volume reduced by seepage reduction per year (AF)	4,200
	Volume reduced by shallow groundwater pumping per year (AF)	0
Other Drainwater Reduction	Volume reduced by recycling per year (AF)	23,800
	Acres of land fallowing	0
Drainage Rate After Drainwater Reduction	Drainage volume per year (AF)	108,900
Drainage Reuse	Volume reduction in Northerly Area per year (AF)	25,700
	Volume reduction in Westlands North per year (AF)	18,700
	Volume reduction in Westlands Central per year (AF)	18,700
	Volume reduction in Westlands South per year (AF)	16,500
Drainage Rate After Reuse	Drainage volume in AF/acre/year (average)	29,400
	Drainage flow rate in cfs (average)	41
Treatment	Average Se concentration of reused drainwater (µg/L)	361
	Volume to Se biological treatment per year (AF)	29,400
	Volume to RO treatment per year (AF)	0
	Volume to TD/EES treatment per year (AF)	0
	Average Se concentration at point of discharge (µg/l)	72
Land Conveyance	Miles of pipe	63.9
	Miles of new canal	60.1
	Miles of existing canal	83
Under Water Conveyance	Miles of tunnel pipe under water	0
	Miles of suspended pipe under water	0
	Miles of buried pipe under water	1
Total Conveyance	Total miles of conveyance	208
Energy Use/Generation	Energy requirements for conveyance (kw-hr/year)	17,150,000
	Energy requirements for lagoon treatment (kw-hr/year)	2,506,000
	Energy generated (kw-hr/year)	NA
Land Requirements	Acres of reuse	27,200
	Acres of Se treatment facility (flow 41*1.2)	160
	Acres of evaporation ponds	NA
	Acres of temporary right-of-way[1]	1,150
	Acres of permanent right-of-way (pipeline) [2]	250
	Acres of permanent right-of-way (canal)	560
	Acres of required mitigation	TBD
Biology	Acres of sensitive habitat impacted	120
Drainwater Reclamation	Volume of water reclaimed per year (product water) (AF)	NA
	Tons of salt generated for reuse	NA

Notes:
[1] Includes temporary right-of-way for 2 pumping plants and regulating tanks (8 acres), pipeline (75 feet wide) and canal (100 feet wide).
[2] Includes permanent right-of-way for 2 pumping plants and regulating tanks (6 acres), pipeline (30 feet wide) and canal (100 feet wide

NA = not applicable to this Disposal Alternative.
TBD = to be determined in future detailed analysis.

Table 5.4-4
Delta-Carquinez Strait Disposal Alternative,
Present Worth of Total Project Costs

Project Features	Present Value ($1,000)	Annual Equivalent ($1,000)
FEDERAL PROJECT COSTS		
Federal Costs - Alternative Specific		
Conveyance System	361,760	22,552
Evaporation Ponds	0	0
Evaporation Pond Mitigation Facilities	0	0
Reverse Osmosis Facilities	0	0
Biological Selenium Treatment	135,180	8,427
Subtotal - Alternative Specific Federal Costs	496,940	30,979
Common Federal Costs		
Drainage Collection System	362,929	22,625
Regional Reuse Facilities	48,765	3,040
Subtotal - Common Federal Costs	411,693	25,665
SUBTOTAL - FEDERAL PROJECT COSTS	**908,633**	**56,644**
NONFEDERAL PROJECT COSTS		
Drainwater Reduction Measures		
Drainwater Recycling	19,726	1,230
Seepage Reduction	8,091	504
Shallow Groundwater Management	16,151	1,007
Subtotal - Drainwater Reduction	43,968	2,741
On-Farm Tile Drainage System	126,099	7,861
SUBTOTAL - NONFEDERAL PROJECT COSTS	**170,067**	**10,602**
TOTAL PROJECT COSTS	**1,078,700**	**67,246**

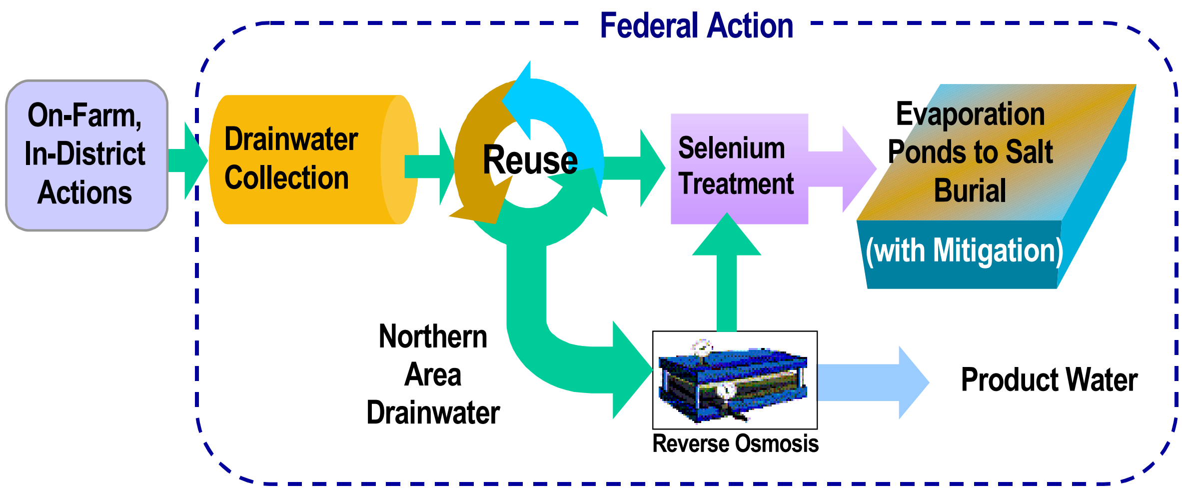


Figure 5.5-1 Components of the In-Valley Disposal Alternative

The key components of this alternative are:

On-Farm, In-District Actions – Drainwater recycling, shallow groundwater management, and seepage reduction implemented by farmers and/or water districts to reduce drainwater volumes.

Drainwater Collection – Reclamation would construct a closed collection system to collect and convey drainwater from on-farm subsurface tile drains to the regional reuse facilities.

Regional Reuse – Four regional reuse facilities would irrigate salt tolerant crops with drainwater. Drainwater from the reuse facility would be collected and conveyed to treatment facilities.

Reverse Osmosis – Reclamation determined that reverse osmosis treatment of the reuse drainwater is a cost-effective treatment technology in the Northerly Area. Reverse osmosis would remove salts and other contaminants from the drainwater, producing high quality water. This desalted product water would be blended with Central Valley Project water and used for commercial crop irrigation. The RO treatment plant would also produce a concentrated waste stream requiring further selenium treatment and disposal. Reclamation determined that reverse osmosis would not be cost-effective for treating reuse drainwater from Westlands because of the higher hardness of the drainwater (higher concentrations of calcium and other minerals). Reverse osmosis would recover approximately 50 percent of the reuse drainwater in the Northerly Area for irrigation.

Selenium Biotreatment – Reused drainwater from Westlands and the concentrate from the reverse osmosis facility would be treated to remove selenium and reduce the environmental risk of evaporation pond disposal. Treatment would consist of the biological removal of selenium in aerated lagoons. To prevent seepage into local groundwater supplies, each lagoon would consist of a concrete bottom with a secondary plastic liner. Floating covers on the lagoons would prevent oxygen interference with the process, reduce operating costs, and prevent wildlife access to the lagoon water. Selenium treatment produces a small amount of sludge (holding the concentrated selenium) that would be transported offsite for disposal as a hazardous material. For planning purposes, an 80 percent removal rate was used.

Evaporation Ponds – Treated drainwater from the selenium treatment facilities would be collected and conveyed to two regional evaporation pond systems. These evaporation ponds would be constructed as needed through the planning period to a total planned acreage of approximately 5,000 acres. Salts precipitate and accumulate at the bottom of the ponds during evaporation and would require periodic excavation and burial of accumulated salts. Excavation and burial would not likely be required until after 80 to 100 years of operation. To maintain capacity, additional evaporation ponds would then need to be constructed to replace ponds used for salt burial, if needed.

Mitigation Facilities – Mitigation habitat would be required to compensate for potential adverse impacts to waterfowl and shorebirds exposed to elevated levels of Se (>2 ppb) within the evaporation ponds. The quantity of land required for mitigation depends on the concentration of Se within the ponds and other site-specific conditions, some of which would not be known until the ponds are operational and actual waterbird use can be monitored. Reclamation estimated that 3,200 to 6,400 acres of mitigation facilities would be required.

Potential locations for reuse, treatment, evaporation, and mitigation facilities have been identified for the purposes of preparing preliminary designs and costs and are shown on Figure 5.5-2. Similarly, a possible pipeline alignment with pumping stations to convey drainwater to these facilities is also shown on Figure 5.5-2. Final selection of conveyance and facility locations will require additional field investigations and data analysis to evaluate a variety of engineering and environmental parameters (e.g., soils, groundwater, land use, and endangered and protected species). Identification of the potential locations was based on a variety of existing information that indicates that they may be suitable for their intended purposes. Table 5.5-1 summarizes the key features of this alternative. These features are described in more detail below.

Table 5.5-1
Summary of Features and Specifications, In-Valley Disposal Alternative (2050)

Component	Characteristic	
Drainage Area	Acres with tile drains installed by 2050	236,200
On-Farm Drainwater Reduction	Volume reduced by improved irrigation per year (AF)	0
	Volume reduced by shallow-water management per year (AF)	4,700
Regional Drainwater Reduction	Volume reduced by seepage reduction per year (AF)	4,200
	Volume reduced by shallow groundwater pumping per year (AF)	0
Other Drainwater Reduction	Volume reduced by recycling per year (AF)	23,300
	Acres of land fallowing	0
Drainage Rate After Drainwater Reduction	Drainage volume per year (AF)	106,700
Drainage Reuse	Volume reduction in Northerly Area per year (AF)	25,700
	Volume reduction in Westlands North per year (AF)	17,600
	Volume reduction in Westlands Central per year (AF)	18,300
	Volume reduction in Westlands South per year (AF)	16,300
Drainage Rate After Reuse	Drainage volume in AF/acre/year (average)	28,800
	Drainage flow rate in cfs (average)	40
Treatment	Average Se concentration of reused drainwater (µg/L)	361
	Volume to Se biological treatment per year (AF)	24,100
	Volume to RO treatment per year (AF)	9,500
	Volume to TD/EES treatment per year (AF)	0
	Average Se concentration in influent to northern evap ponds (µg/l)	120
	Average Se concentration in influent to southern evap ponds (µg/L)	39
Land Conveyance	Miles of pipe	65
	Miles of canal	NA
Underwater Conveyance	Miles of tunnel pipe under water	NA
	Miles of suspended pipe under water	NA
	Miles of buried pipe under water	NA
Total Conveyance	Total miles of conveyance	65
Energy Use/Generation	Energy requirements for conveyance (kw-hr/year)	8,600,000
	Energy requirements for RO treatment (kw-hr/year)	22,000,000
	Energy requirements for lagoon treatment (kw-hr/year)	2,445,000
	Energy generated (kw-hr/year)	NA
Land Requirements	Acres of reuse	26,700
	Acres of RO treatment facility	6
	Acres of Se treatment facility (flow 40*1.2)	160
	Acres of northern evaporation pond	2,368
	Acres of southern evaporation pond	2,695
	Acres of temporary right-of-way[1]	600
	Acres of permanent right-of-way [2]	240
	Acres of required mitigation (0.9 to 1.8 acres mit/acre evap pond for northern ponds and 0.4 to 0.8 mit/acre evap pond for southern ponds)[3]	3,200–6,400
Biology	Acres of sensitive habitat impacted[3]	0
Drainwater Reclamation	Volume of water reclaimed per year (product water) (AF)	4,750
	Tons of salt generated for reuse	0

Notes:
[1]Includes temporary right-of-way for 4 pumping plants and regulating tanks (12 acres).
[2]Includes permanent right-of-way for 4 pumping plants and regulating tanks (8 acres).
[3] Identified during current appraisal-level analysis.

Figure 5.5-2 In-Valley Disposal Alternative Features

5.5.1.1 Reverse Osmosis Treatment

Reused drainwater from the Northerly Area would be treated by an RO plant to produce high quality product water that could be blended with CVP water for use in irrigation. The plant would treat the average annual flow rate from the Northerly Area reuse facility, which is expected to be about 9,500 AF/year. The RO system would consist of a single-stage, single-pass array to achieve 50 percent recovery and would produce about 4,750 AF/year of product water and 4,750 AF/year of concentrated drainwater. A schematic of the RO treatment plant operation is shown on Figure 5.5-3.

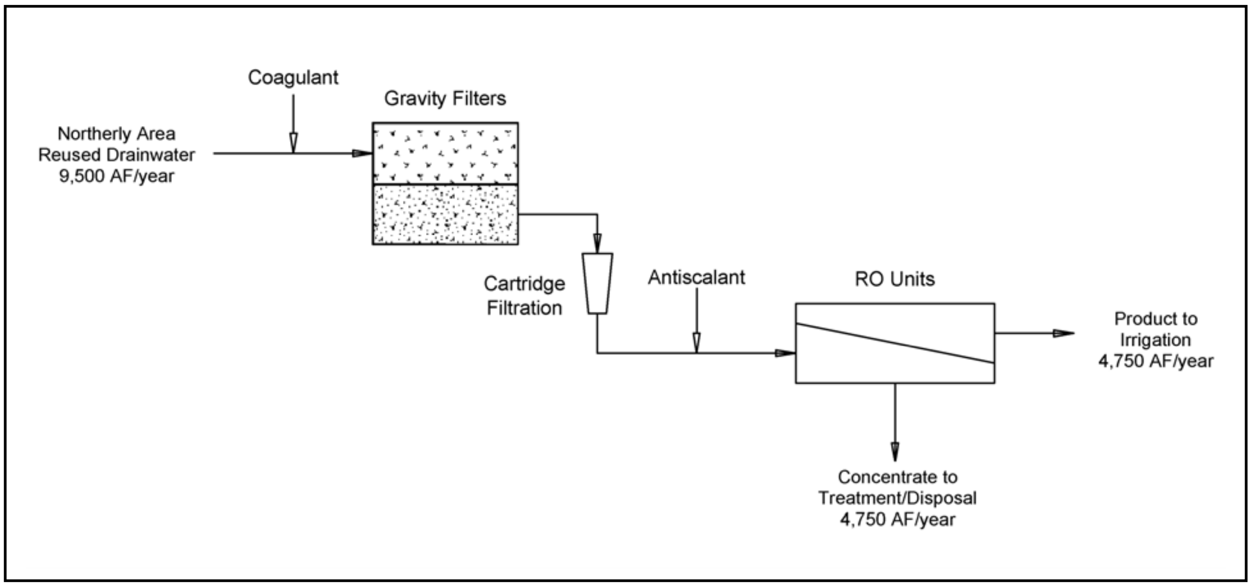


Figure 5.5-3 Schematic of RO Treatment Plant

Filtration of reused drainwater would be required to remove suspended particles and colloids that can potentially cause fouling of the RO membrane surfaces. Filtration would consist of rapid sand filters followed by cartridge filters. A coagulant chemical would be injected upstream of the gravity filters to agglomerate the colloids and suspended matter into larger particles that are easier to filter. An antiscalant chemical would be injected into the filtered drainwater to prevent scale formation on the membranes.

The RO facility would be comprised of a main treatment building, outdoor treatment components, and appurtenant structures occupying about 6 acres. It is assumed that the product water would be conveyed to and blended with CVP water in a nearby canal. The concentrate stream would be conveyed to a biotreatment facility for removal of Se and later to an evaporation facility for disposal.

5.5.1.2 Selenium Biotreatment

Reused drainwater from Westlands would be treated for Se removal to reduce the environmental risk of evaporation pond disposal. In addition, concentrate stream from the RO facility would also be conveyed to a Se treatment facility prior to disposal at the evaporation ponds. The concentrate stream from the RO facility and the reused drainwater from Westlands North would be conveyed via pipeline to a northern Se treatment facility located adjacent to the possible northern evaporation ponds complex located in Westlands North and shown on Figure 5.5-2. The reused drainwater from Westlands Central and South would be conveyed via pipeline to a southern Se treatment facility located adjacent to the possible southern evaporation pond complex located in between Westlands Central and South and shown on Figure 5.5-2. The design flow rate for the treatment facilities are 16 and 17 cfs for the northern and southern treatment facilities, respectively. However, for costing and sizing of the treatment facility, flows of 19 and 21 cfs (16 cfs and 17 cfs times a 1.2 variability factor) were used for the northern and southern treatment facilities, respectively, to account for the redundancy of the treatment components required for maintenance and/or temporary shutdown. Treatment would consist of the biological removal of Se, as described in Section 5.4 for the Delta Disposal Alternatives.

5.5.1.3 Evaporation Ponds

Effluent from the northern Se biotreatment facility would be conveyed to the northern evaporation facility. Effluent from the southern Se biotreatment facility would be conveyed to the southern evaporation facility (see Figure 5.5-2). Preliminary designs and costs for evaporation ponds assume the following features:

- Bottom of ponds would be constructed using natural clay liners from native soils to reduce permeability below 10^{-6} cm/s.
- Ponds would be located where underlying groundwater is not potable and not considered to be a source of drinking water (i.e., TDS > 3,000 mg/L).
- Ponds would be located above the 100-year floodplain.
- Ponds would be located in areas with gently sloped terrain.
- Ponds would not be located within the habitats of endangered or protected species.
- Techniques would be used that minimize adverse biological impacts associated with wildlife exposure to Se, including maintaining pond depths > 4 feet, vegetation control, no islands or wind breaks, side slopes at least 3:1, and hazing of waterfowl.
- Net evaporation rate is 4.75 feet/year (including precipitation and loss from seepage).
- Location would be in close proximity to drained agricultural lands.
- Se concentrations within ponds would be kept below levels designated as hazardous waste.
- Se concentrations within precipitated salts are below levels designated as hazardous waste.
- Site closure would entail in-place burial of precipitated salts, placement of low-permeability soil cap, grading to control runoff and ponding of precipitation, establishment of vegetation to minimize erosion, and long-term monitoring of selected biota and the underlying groundwater.

Evaporation ponds have been used in San Joaquin Valley for about two decades as a means of disposal of irrigation drainwater. About 4,000 acres of evaporation ponds are currently in operation within the Valley, most or all of which incorporate the above features. Existing information from a variety of sources was analyzed to locate additional areas within San Joaquin Valley that meet the above siting criteria. The available information indicates a reasonable probability that the two regional pond facility locations shown on Figure 5.5-2 meet these criteria.

The concentration of Se within the evaporation ponds increases during evaporation; however, other physical, chemical, and biological processes within the pond environment act to reduce the concentration of dissolved Se species. The magnitude of Se reduction that occurs through these processes appears to be related to site-specific conditions based on information derived from existing pond operations. These processes are not well understood and are not easily quantified or modeled. Therefore, estimates of the concentration of Se within the evaporation ponds are not presented, although they are expected to remain substantially below the regulatory level of 1,000 ppb.

Salts would precipitate and accumulate at the bottom of the ponds during the evaporation process at the rate of 100,000 to 700,000 tons/year. It is estimated that the depth of accumulated salts would range from 12 to 18 inches at the end of the 50-year planning period. Presumably the evaporation ponds would continue to operate indefinitely until no longer needed; however, periodic excavation and burial of accumulated salts would be required. The salts would be consolidated and buried within some of the existing evaporation cells. The process would entail excavation of salts and about 3 inches of underlying soil. Excavated material would be hauled to the selected storage location and compacted to a depth of about 5 feet. The surface would be capped with a compacted 12 inch layer of soil followed by vegetation seeding.

5.5.1.4 Mitigation Facilities

Mitigation habitat would likely be required to compensate for adverse physiological and reproductive impacts to waterfowl and shorebirds exposed to elevated levels of Se (>2 ppb) within the evaporation ponds. These impacts would be considered especially significant for species protected under the Migratory Bird Treaty Act (MDTA) and Endangered Species Act (ESA). Construction of Se-safe mitigation facilities would (1) provide attractive (to waterbirds) uncontaminated alternative foraging and nesting habitat, thus reducing overall contaminant exposure in the landscape surrounding the ponds, and (2) compensate for documented cases of Se-related mortality and reproductive failure.

The quantity of land required for mitigation depends on the concentration of Se within the ponds and other site-specific conditions, some of which would not be known until the ponds are operational and actual waterbird use can be monitored. Possible locations for the mitigation facilities are shown in Figure 5.5-2. Preliminary designs and costs for the mitigation facilities assume the following features:

- Half of each proposed mitigation facility would be developed into wetland habitat and half into uplands. Wetland habitats would consist of a mix of shorebird nesting and foraging habitat, seasonal (moist soil management) wetlands and semi-permanent ponds for migratory waterfowl, and some permanent ponds. Upland habitats would consist of areas of native and non-native grasses and/or shrubs, as well as irrigated areas producing small grains, corn, or other forage or cover crops suitable for waterfowl and other wildlife species.
- Approximately half of the area developed as wetland habitat would consist of shallow shorebird habitat similar to the mitigation wetlands developed by Tulare Lake Irrigation District for its evaporation ponds. The remaining wetlands would consist of seasonal,

semi-permanent, and permanent ponds maintained largely to benefit migrating waterfowl.

- All water supplied to the mitigation facilities would be of high quality (Se < 2 ppb) and would be obtained from water allocations acquired with irrigated land purchased for project purposes (e.g., re-use areas, evaporation ponds, or mitigation lands). Based on a conservative conceptual design that incorporates the above mix of wetland and upland habitats, it is estimated that a total of 12,000 to 25,000 AF/yr would be required to operate and maintain the anticipated 3,200 to 6,400 acres of mitigation needed for the In-Valley Alternative's proposed 5,063 acres of evaporation ponds.
- Sites selected for mitigation facilities would have soil and groundwater properties suitable for wetland development and sustained long-term operation. Suitable properties would include appropriate permeability, soil and groundwater chemistry, and depth to groundwater.
- Electric fencing would be installed and maintained around the perimeter of shorebird nesting areas to exclude predators.

5.5.2 Implementation Schedule and Costs

A preliminary implementation schedule was developed for In-Valley Disposal Alternative (Figure 5.5-4). Factors used in developing the schedule include permitting, engineering design, land acquisition, and construction. The schedule assumes that land acquisition and engineering design would occur concurrent with permitting activities. Construction of project features includes first-phase components of the drainage collection system, drainage reduction measures, reuse facilities, treatment plants, evaporation ponds, conveyance, and mitigation.

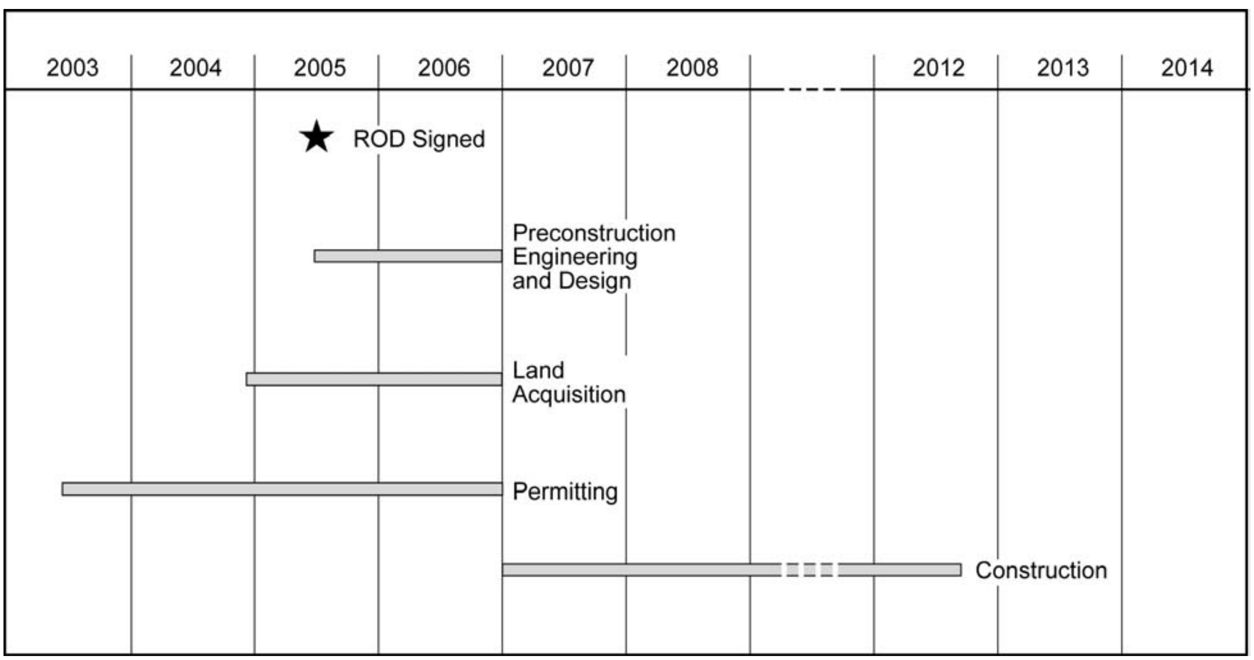


Figure 5.5-4 In-Valley Disposal Alternative Implementation Schedule

The total drainage capacity needed over the 50-year project period would be constructed in two phases because drainage flows would increase gradually during this period. About 50 percent of the total capacity needed for reuse, biotreatment, evaporation and mitigation would be constructed initially. The other 50 percent would be constructed when needed, after about 15 years. For this alternative, disposal facilities would not need to be completed for the entire study area before drainage services would begin.

The summary of the present value and estimated annual equivalent costs for the In-Valley Disposal Alternative at 40 cfs is included in Table 5.5-2. The assumptions for development of these cost estimates are discussed in Section 5.6.

Table 5.5-2
In-Valley Disposal Alternative,
Present Worth of Total Project Costs

Project Features	Present Value ($1,000)	Annual Equivalent ($1,000)
FEDERAL PROJECT COSTS		
Federal Costs - Alternative Specific		
Conveyance System	87,356	5,446
Evaporation Ponds	51,686	3,222
Evaporation Pond Mitigation Facilities	43,561	2,716
Reverse Osmosis Facilities	71,739	4,472
Biological Selenium Treatment	113,338	7,065
Subtotal - Alternative Specific Federal Costs	**367,679**	**22,921**
Common Federal Costs		
Drainage Collection System	362,929	22,625
Regional Reuse Facilities	48,765	3,040
Subtotal - Common Federal Costs	**411,693**	**25,665**
SUBTOTAL - FEDERAL PROJECT COSTS	**779,373**	**48,586**
NONFEDERAL PROJECT COSTS		
Drainwater Reduction Measures		
Drainwater Recycling	19,726	1,230
Seepage Reduction	8,091	504
Shallow Groundwater Management	16,151	1,007
Subtotal - Drainwater Reduction	43,968	2,741
On-Farm Tile Drainage System	122,493	7,636
SUBTOTAL - NONFEDERAL PROJECT COSTS	**166,461**	**10,377**
TOTAL PROJECT COSTS	**945,834**	**58,963**

5.6 SUMMARY OF COST ESTIMATES AND ASSUMPTIONS

Cost estimates for each alternative were prepared in accordance with Reclamation instructions for appraisal studies. Appraisal-level cost estimates are based mostly on existing information with a very limited amount of new data but are adequate to support a preliminary assessment of alternatives. The level of data and sophistication of the analyses are adequate to support a decision as to whether the alternatives should be carried forward for more detailed analyses and cost estimates (i.e., feasibility level) or eliminated from further studies. This decision is necessarily subjective, based on existing data, input from various specialists, and the judgment of Reclamation. The cost estimates for each alternative were developed in a similar fashion as explained below:

1. Existing information regarding topography, land use, soil type, groundwater quality, and environmental parameters was used to select preliminary locations for the component features of each alternative.
2. Size and capacity of the features were determined based on projections of drainwater quantity and quality over a 50-year period.
3. Typical design layouts, preliminary locations, and capacities were used to calculate quantities of items needed to construct features.
4. Quantities of items needed to operate and maintain the features over a 50-year period were estimated.
5. Current unit or lump sum costs were obtained for each of the listed construction, operation, and maintenance items. These costs were obtained through a variety of sources including vendor quotes, construction cost publications, utilities, construction firms, cost data from previous projects, and cost curves. Cost information from previous years was updated to year 2002 dollars using cost indices.
6. For appraisal studies the level of detail does not warrant a complete listing of all the minor construction items. Minor unlisted items were accounted for by adding 15 percent of the total itemized construction cost. The sum of the listed and unlisted items is referred to as the Contract Cost.
7. A contingency was added to the Contract Cost for additional costs incurred after the contract is awarded and construction begins. This contingency (25 percent of the Contract Cost) covers quantity overruns, changed site conditions, change orders, etc. The sum of the Contract Cost and the contingency is referred to as the Field Cost.
8. Non-contract costs were added to account for site investigations, final design, contract administration, and construction oversight. The non-contract costs were estimated as 33 percent of the Field Cost. The sum of the Field Cost and the non-contract costs is referred to as the Total Construction Cost.
9. The cost comparison of the alternatives was based on an economic analysis that discounted costs at 5.875 percent over a 50-year period.

The summary of the estimated annual equivalent costs for all Disposal Alternatives are included in Table 5.6-1.

Table 5.6-1
All Alternatives
Present Worth of Total Project Costs

Summary of Project Costs ($ millions, 2002 dollars)

Alternatives	Federal Cost[1] Construction	Federal Cost[1] Annual O&M	Federal Cost[1] Present Worth	Total Cost Annual Equivalent	Total Cost Present Worth
In-Valley	715	16.3	779	59.0	946
Delta-Chipps	763	14.6	836	62.7	1,006
Delta-Carquinez	833	14.6	908	67.2	1,079
Ocean	920	17.5	1,013	73.7	1,183

Federal Cost – Costs for facilities that would be part of the Federal drainage service plan and are federally funded. See Section 5.2 for the components that would be Federal facilities.

Total Cost – The Federal Cost plus the cost for all on-farm/in-district drainwater reduction measures.

Construction – All capital costs for lands, rights-of-way, construction, mitigation, and interest during construction, displayed in 2002 dollars.

Annual O&M – All costs required each year to operate and maintain project facilities, displayed in 2002 dollars, including energy costs.

Present Worth – The combined construction and annual O&M costs presented as a one-time cost, displayed in 2002 dollars.

Annual Equivalent – The present worth cost presented as a series of equal annual payments over 50 years.

[1] The Federal costs for each of the action alternatives would exceed the current Federal spending limit authorized under the San Luis Act.

SECTIONSIX

PRELIMINARY IMPACT ANALYSIS

This section summarizes the preliminary analysis of environmental impacts for each of the Disposal Alternatives. The regulatory environment is part of the affected environment used as a baseline for determining environmental impacts. It is included as Appendix F. The entire preliminary impact analysis is included in Appendix G. **This analysis is intended to support the alternatives selection process and to provide input into the upcoming EIS.** A complete EIS will be prepared in 2003 covering the proposed action, other reasonable alternatives, and the No Action Alternative. Table 6-1 provides a summary of potential adverse and beneficial impacts of the disposal alternatives for the following resources and environmental concerns:

- Water quality and quantity (surface- and groundwater resources)
- Biological resources
- Geology
- Energy resources
- Air quality
- Agricultural production and economics
- Land use
- Aesthetics
- Social issues and environmental justice
- Cultural resources
- Public concern

The symbols used in this table are:

- +: beneficial impact
- –: adverse impact
- 0: minor or no impact
- ?: unknown

The text following Table 6-1 summarizes the adverse impacts of the disposal alternatives on each of the resources and environmental concerns listed above.

Table 6-1
Estimated Environmental Impact Summary Relative to the No Action Scenario

Resource	Anticipated Environmental Effect	Out-of-Valley: Ocean Disposal: Point Estero	Out-of-Valley: Delta Disposal: Chipps Island	Out-of-Valley: Delta Disposal: Carquinez Strait	In-Valley Disposal
Water Quality and Quantity	**Surface Water**				
	Salinity in Delta drinking water intakes	+	0	0	+
	Water quality in San Joaquin River and tributaries	+	+	+	+
	Se in Bay-Delta waterfowl	0	–	–	0
	Groundwater				
	Bare-soil evaporation	+	+	+	+
	Area affected by shallow-water table	–	–	–	–
	Groundwater salinity	+	+	+	+
Biological Resources	Terrestrial Resources	–	–	–	–
	Aquatic Resources	0	–	–	–
	Special-Status Species	–	–	–	–
Geology	Land Subsidence	–	?	?	–
	Faulting	–	–	–	0
	Landslides	–	0	0	0
Energy Resources	Energy Use	–	–	–	–
Air Quality	Emissions	–	–	–	–
Agricultural Production and Economics	Agricultural lands in production	+	+	+	+
	Irrigation and salinity management costs	+	+	+	+
	Crop yields and revenues	+	+	+	+
Land Use	**Recreation**				
	Wildlife viewing/hunting	0	0	0	0
	Ocean-based recreation	0	0	0	0
	Delta recreation	0	0	0	0
	Agriculture	+	+	+	+
Aesthetics	Visual Characteristics	–	–	–	–
Social Issues and Environmental Justice	Social Issues	?	?	?	?
	Environmental Justice	0	0	0	0
Cultural Resources	Cultural Resource Types	–	–	–	–

+: beneficial impact   0: minor or no impact
–: adverse impact   ?: unknown

6.1 WATER QUANTITY AND QUALITY

A series of modeling exercises were undertaken in this study to determine what effects to receiving waters may occur as a consequence of the alternatives at each of the Out-of-Valley Disposal Alternatives discharge locations (see Appendix G1). The findings of the modeling exercises are summarized below for both surface and ground waters.

6.1.1 Ocean Disposal Alternative

Concerning ocean waters off Point Estero, the mixing zone above the diffuser would be required to achieve compliance with the ocean plan criteria of 15 ppb for Se. A preliminary diffuser design was modeled using U.S. Environmental Protection Agency (EPA) Visual Plumes software to determine an approximate size of the mixing zone. Under worst-case ocean current conditions (i.e., zero velocity), the resulting Se plume would reach a concentration of 15 ppb at a minimum depth of approximately 48 meters (m) under winter temperature conditions. For this scenario, the plume would be a maximum of approximately 3.1 m wide and 87 m long. Under maximum ocean current conditions (both summer and winter), the 15 ppb criterion would be achieved approximately 1 m above the diffuser ports. The plume would be approximately 1 m wide and 85 m long.

Groundwater levels in the study area are predicted to increase through the 50-year modeling period, causing an additional 150 square miles of land to become drainage impaired (shallow groundwater within 7 feet of the ground surface). Groundwater salinity is predicted to increase slightly through the modeling period as a result of the regional drainwater recycling, although this increase is less than predicted under No Action. These changes are offset by the general improvements gained by the removal of shallow groundwater from the study area by the action alternatives, resulting in a beneficial change.

6.1.2 Delta-Chipps Island Disposal Alternative

A mixing zone above the diffuser would be required to achieve compliance with the 5 ppb water quality criteria for Se in the Delta. Under worst-case conditions (zero current velocity), the mixing zone would be 3.2 m tall, 1.5 m wide, and would extend approximately 60 m across the channel. This size of the mixing zone is similar to other mixing zones that have been granted by the San Francisco Bay Regional Water Quality Control Board (Regional Board) in San Francisco Bay and is not considered a significant adverse effect; however, concerns with bioaccumulation would need to be addressed.

Changes in TDS concentration in the North Bay were assessed using two numerical simulation water quality models. Long-term (1956–1991) modeling of TDS concentrations at the Rock Slough intake operated by the CCWD and Clifton Court Forebay operated by the State and Federal Water Projects was conducted using the Fisher-Delta Model. The results of the long-term simulations are shown in Figures 6.1-1 and 6.1-2. The modeling indicates a small increase in the long-term average TDS concentrations at the two intakes due to the discharge. No increases were greater than 25 mg/L with increases of 5 mg/L occurring less than 30 percent of the time. TDS concentrations in Clifton Court Forebay are predicted to increase by 10 mg/L less than 10 percent of the time. A 2-dimensional model (Danish Hydraulic Institute's MIKE 21) was used to

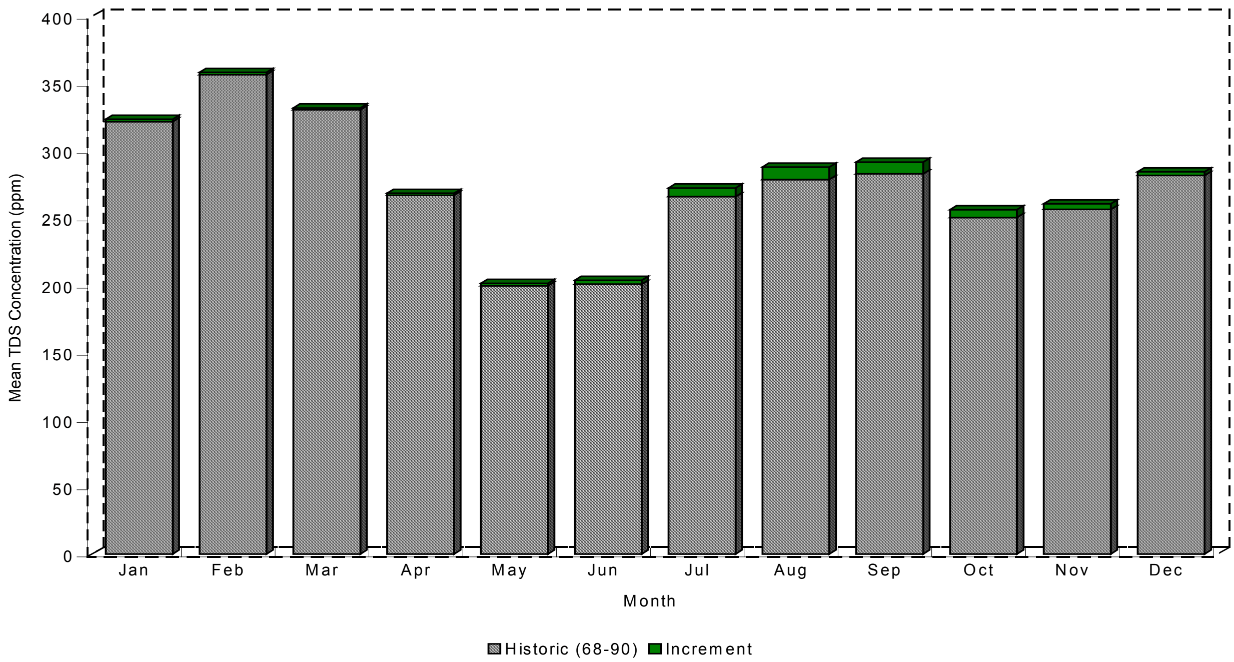


Figure 6.1-1 Contra Costa Intake – Rock Slough, 1956–91, Monthly Mean TDS (Salinity), Mean TDS + Incremental Increase from 41 cfs Discharge at Chipps Island

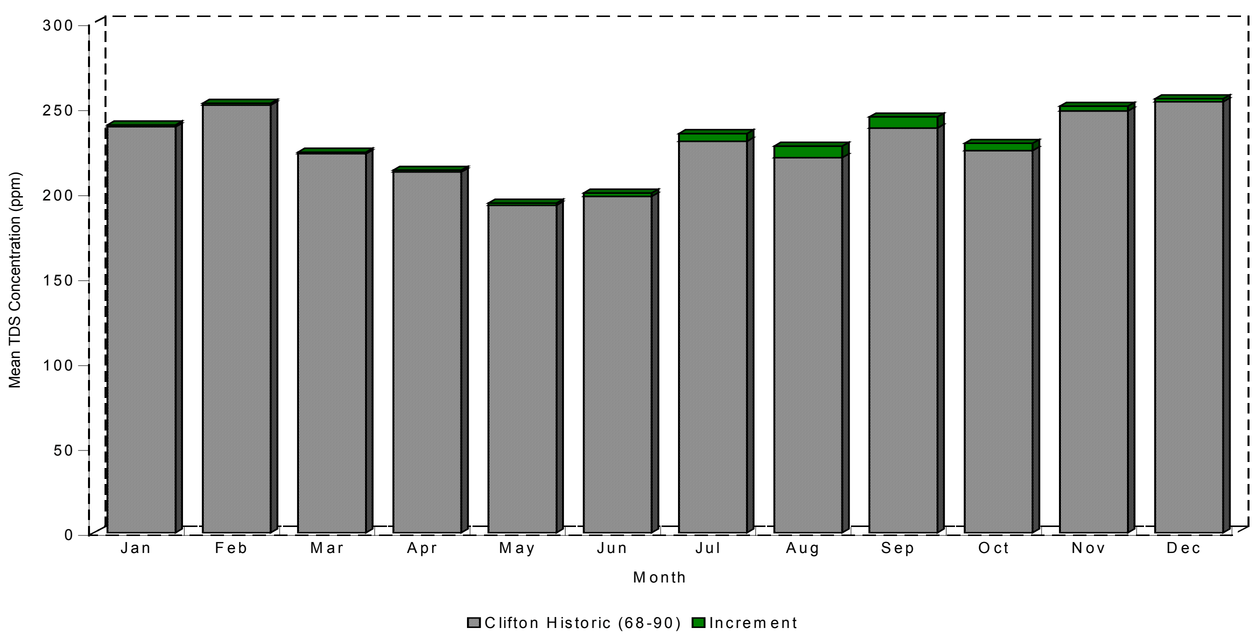


Figure 6.1-2 Clifton Court Forebay, 1956–91, Monthly Mean TDS (Salinity), Mean TDS + Incremental Increase from 41 cfs Discharge at Chipps Island

assess changes in TDS from the North Bay up to Jersey Point in the Delta. Modeled mean TDS concentrations are shown in Figure 6.1-3. During an extreme drought period (July–November 1977) TDS concentrations in the vicinity of Antioch are predicted to increase by 40 mg/L. During the same period increases at Oakley are predicted to be 10 mg/L.

Se water quality modeling indicated during the dry season total Se concentrations in Suisun Bay increase from 0.1 to 0.3 μg/L (Figure 6.1-4). Dissolved Se concentrations increase from 0.1 to 0.25 μg/L. Se concentrations associated with suspended particulates increase from 0.3 to 0.8 μg/kg. The increases do not result in exceedances of the 5 ppb total Se water quality criteria outside of the mixing zone.

Se concentrations in bivalve tissues (clams and mussels) are predicted to increase from 1.5 to 3.5 μg/kg (Figure 6.1-5). These predicted tissue concentrations are less than 4 mg/kg, which has been assigned a hazard ranking of low toxicity in previous investigations. However, uncertainty in the speciation of Se discharged, bioavailability, and transformations in the estuary cause bioaccumulation to be a potentially significant effect.

Groundwater levels in the study area are predicted to increase through the 50-year modeling period, causing an additional 150 square miles of land to become drainage impaired (shallow groundwater within 7 feet of the ground surface). Groundwater salinity is predicted to increase slightly through the modeling period as a result of the regional drainwater recycling, although this increase is less than predicted under No Action. These changes are offset by the general improvements gained by the removal of shallow groundwater from the study area by the action alternatives, resulting in a beneficial change.

6.1.3 Delta-Carquinez Strait Disposal Alternative

A mixing zone above the diffuser would be required to achieve compliance with the 5 ppb water quality criteria for Se. Under worst-case conditions (zero current velocity) the mixing zone would be 3.2 m tall, 1.5 m wide, and would extend approximately 60 m across the channel. This size of mixing zone is similar to other mixing zones that have been granted by the Regional Board in San Francisco Bay and is not considered a significant adverse effect; however, concerns with bioaccumulation would need to be addressed.

Modeled mean TDS concentrations during an extreme drought period (July–November 1977) at Antioch are predicted to increase by 10 mg/L (Figure 6.1-6). During the same period increases at Oakley are predicted to be insignificant.

Se water quality modeling indicated during the dry season total Se concentrations in San Pablo Bay increase from 0.1 to 0.35 μg/L (Figure 6.1-7). Dissolved Se concentrations increase from 0.1 to 0.25 μg/L. Se concentrations associated with suspended particulates increase from 0.3 to 0.8 μg/kg. The increases do not result in exceedances of the 5 ppb total Se water quality criteria outside of the mixing zone.

Se concentrations in bivalve tissues (clams and mussels) are predicted to increase from 1.5 to 3.5 μg/kg (Figure 6.1-8). These predicted tissue concentrations are less than 4 mg/kg, which has been assigned a hazard ranking of low toxicity in previous investigations. However, uncertainty in the speciation of Se discharged, bioavailability, and transformations in the estuary cause bioaccumulation to be a potentially significant effect.

Groundwater levels in the study area are predicted to increase through the 50-year modeling period, causing an additional 150 square miles of land to become drainage impaired (shallow groundwater within 7 feet of the ground surface). Groundwater salinity is predicted to increase slightly through the modeling period as a result of the regional drainwater recycling, although this increase is less than predicted under No Action. These changes are offset by the general improvements gained by the removal of shallow groundwater from the study area by the action alternatives, resulting in a beneficial change.

6.1.4 In-Valley Disposal Alternative

Under this alternative no discharges of drainwater to local surface waters would occur (following conclusion of the Grassland Bypass Project). As a result local surface-water quality would improve in the study area.

Groundwater levels in the study area are predicted to increase through the 50-year modeling period, causing an additional 150 square miles of land to become drainage impaired (shallow groundwater within 7 feet of the ground surface). Groundwater salinity is predicted to increase slightly through the modeling period as a result of the regional drainwater recycling, although this increase is less than predicted under no action. These changes are offset by the general improvements gained by the removal of shallow groundwater from the study area by the action alternatives, resulting in a beneficial change.

6.2 BIOLOGICAL RESOURCES

This section summarizes potential project impacts to rare/protected vegetation communities, protected/regulated habitats, and special status vertebrate, invertebrate, and plant species that may occur in the affected environment of described project features and activities. Potential impacts are broadly grouped into the following categories: **terrestrial**, **aquatic/wetland**, and **special status species** and are described for each alternative. A more detailed preliminary impact analysis of biological resources is included in Appendix G2.

6.2.1 Ocean Disposal Alternative

Implementation of this alternative would result in both temporary and permanent impacts. Both native and disturbed **terrestrial habitat** types would be affected. A total of 59 acres of rare/sensitive terrestrial habitat types, as identified and mapped in the California Natural Diversity Database (CNDDB), would be affected by construction or operation of this alternative, including 56 acres of Valley Oak Woodlands and 3 acres of mostly second terrace Valley Foothill Riparian (in the vicinity of the Salinas River crossing).

Impacts to freshwater **aquatic and wetland habitat** are expected to be largely short-term and less than significant. Because most project features would be located on previously disturbed land or in close proximity to roads and other ROWs, very little sensitive aquatic or wetland habitat would be affected. No major wetland areas, waterfowl management areas or refuges, or significant natural areas were identified from the geographic information system (GIS) overlay analysis of the pipeline corridor. The pipeline would traverse approximately 100 stream crossings (the majority of which are dry washes or intermittent streams) and a very small amount of Coastal Dune habitat. Once the conveyance alignments and related facility locations have

Figure 6.1-3 MIKE 21 Chipps Island Discharge (July-December 1977) Mean Total Dissolved Solids Concentration (TOP), Difference from Existing Conditions (BOTTOM)

Figure 6.1-4 MIKE 21 Chipps Discharge (July-November 1997) Mean Total Selenium Concentration (TOP), Difference from Existing Conditions (BOTTOM)

Figure 6.1-5 Predicted Mean Bivalve Tissue Concentration (Dry Water Year) Adsorbed Selenium Uptake from Chipps Discharge-Predicted (LEFT), Difference (RIGHT)

Figure 6.1-6 MIKE 21 Carquinez Discharge (July-December 1977) Mean Total Dissolved Solids Concentration (TOP), Difference from Existing Conditions (BOTTOM)

Figure 6.1-7 MIKE 21 Carquinez Discharge (July-November 1997) Mean Total Selenium Concentration (TOP), Difference from Existing Conditions (BOTTOM)

Figure 6.1-8 Predicted Mean Bivalve Tissue Concentration (Dry Water Year) Adsorbed Selenium Uptake from Carquinez Discharge-Predicted (LEFT), Difference (RIGHT)

been finalized, wetland delineations will be conducted to identify all wetland crossings, all navigable waters, and other waters of the United States, as defined in Sections 401/404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

Preliminary modeling of the drainwater discharge at the Point Estero outfall has been completed and initial results have been evaluated. **Se concentrations** in the effluent are expected to quickly dilute to less than 15 ppb within a compact mixing zone during both summer and winter temperature and ocean current conditions. Because of the high dilution capacity of the ocean environment, far-field effects of the discharge are expected to be insignificant. These initial results suggest that water quality criteria established under the California Ocean Plan to protect aquatic life, marine and freshwater habitats, commercial and sport fishing, and other designated beneficial uses would be met.

Based on a cursory review of the literature and an appraisal-level reconnaissance of the proposed facility sites and pipeline alignment, 57 **special status species** potentially could be affected to varying degrees from implementation of this alternative. Of the 57 special status species that have medium or high potential for occurrence in areas disturbed by construction, 40 would likely be affected to a less-than-significant level, and 16 would be affected to a less-than-significant level if standard protocols and mitigation measures designed to avoid or protect the species were implemented. Only one species, the southern sea otter, has the potential to be affected by this alternative in a manner that could result in significant, unavoidable impacts. The sea otter is known to forage in the vicinity of the Point Estero outfall, and could presumably forage within the construction disturbance zone, or the initial dilution zone, where elevated Se in the discharge could contaminate prey species. Preliminary modeling of the ocean discharge plume suggests that the discharge would not create a significant contamination hazard for the species; however, additional evaluation may be needed.

Construction of the pipeline within designated **red-legged frog critical habitat** was initially identified as a major concern for this alternative, although most impacts would be temporary or would be reduced to less-than-significant levels with appropriate avoidance and site restoration measures. Approximately 380 acres of critical habitat were initially identified as occurring within the proposed pipeline corridor. However, in November 2002 a final judgment was recorded in U.S. District Court that vacated and remanded the designation of all red-legged frog critical habitat in California (U.S. District Court 2002). While the designation of critical habitat for the red-legged frog has temporarily been rescinded, the species' protected status under the ESA still remains in full effect. Subsequently, any impact avoidance and site restoration measures that originally would have been considered appropriate under this alternative would still be implemented. Actual acres of occupied and potential red-legged frog habitat that could be affected by the project will be determined precisely during field surveys. It is anticipated that the affected acreage will be significantly less (perhaps 25 percent or less) than the 380 acres that was approximated from the U. S. Fish and Wildlife Service (Service) critical habitat map. Presently, it is not anticipated that additional land would be acquired for mitigation purposes.

6.2.2 Delta Disposal Alternatives

Implementation of either of the Delta Disposal Alternatives would result in temporary and permanent impacts to both natural and disturbed **terrestrial habitat types**. The aqueduct for the Delta-Chipps Island Disposal Alternative would disturb approximately 1,127 acres.

Approximately 90 percent of the alignment would traverse agricultural and urban habitats. Nearly 10 percent would cross annual grassland habitat. The aqueduct for the Delta-Carquinez Strait Disposal Alternative would disturb approximately 1,332 acres. Approximately 83 percent of the alignment would traverse agricultural and urban habitats, while 13 percent would cross annual grasslands. Both alignments would follow existing highway, canal, railroad, and powerline ROWs. At the current level of analysis, none of the terrestrial habitat within the proposed alignment would be considered sensitive.

Potential impacts to **aquatic and wetland resources** from construction of the Delta aqueducts would be limited to stream and wetland crossings, although a very small chance of intersecting vernal pool habitat may exist along the approximately 10 to 13 percent of the aqueducts that traverse annual grassland vegetation. For the first 90.6 miles, the alignment for both Delta Disposal Alternatives is identical. From the current terminus of the San Luis Drain, extending northward for a distance of approximately 7.6 miles, the aqueduct would traverse a large wetland complex consisting of State Waterfowl Areas, National Wildlife Refuges, and private duck clubs. Portions of this segment would be considered sensitive habitat. This segment would be constructed as a buried pipeline to reduce the width of the construction corridor and to eliminate permanent impacts to the adjacent wetlands and native uplands. Both alternatives would cross a number of stream channels, although many of the streams are now little more than intermittent swales and agricultural drains. The shorter Chipps Island alignment would cross 21 stream channels, while the Carquinez Strait alignment would cross 30 channels. All crossings would be restored to original contours and revegetated following construction.

Both alternatives could also disturb areas of Coastal Brackish Marsh (a rare community identified and mapped in the CNDDB [CDFG 2001]). The Delta-Chipps Island Disposal and the Delta-Carquinez Strait Disposal Alternatives could affect up to 1.0 and 39.5 acres, respectively, of this sensitive wetland habitat. Actual construction impacts would depend on the extent of excavation that would occur along the dry perimeter of the marsh, in upland ruderal habitat along the railroad berm adjacent to the marsh, or within the marsh itself. Any excavation that would take place in the wetland (as opposed to the adjacent or interspersed ruderal uplands) would be considered significant.

Impacts to **estuarine aquatic habitat** would occur during construction of the underwater outfalls of either Delta Disposal Alternative. These impacts would be of short duration, but could be considered significant if construction were to occur during certain life stages of listed anadromous fish. Preliminary modeling of the discharge plumes at both outfall locations suggests that a mixing zone would be needed above the diffusers to meet the aquatic life criteria established for the Delta to protect aquatic life, marine and freshwater habitats, threatened and endangered species, commercial and sport fishing, and other designated beneficial uses (currently 5 ppb). While the discharge of drainwater is not expected to result in exceedance of the Se criteria outside the mixing zone, the incremental increases in either dissolved concentrations or concentrations adsorbed to suspended or benthic particulate matter may enhance bioaccumulation in organisms. Toxicological effects in higher trophic level species (e.g., fish and waterbirds) could occur in affected areas of the Delta currently exhibiting the highest Se concentrations, especially if more bioavailable forms of Se are present.

Based on a cursory review of the literature and an appraisal-level reconnaissance of the proposed pipeline alignments, it was determined that 46 **special-status species** have a moderate to high potential for occurrence in areas that could be disturbed by the Delta Disposal Alternatives. Of the 46 species, 33 would likely be affected to a less-than-significant level and 4 would be affected to a less-than-significant level if standard protocols and mitigation measures designed to avoid or protect the species were to be implemented. Designated critical habitat for the red-legged frog, totaling approximately 9.2 acres, was identified within the pipeline corridor for both alternatives; however, the critical habitat designation for the species was recently rescinded and may not be reinstated until 2005 or later (U.S. District Court 2002).

Only 9 of the 46 listed species have a potential to be affected by the Delta Disposal Alternatives in a manner that could produce significant unavoidable impacts. These species (all special status fish) are known to breed in or migrate through the Delta in the vicinity of both the Chipps Island and the Carquinez Strait outfalls. Presumably, any of these species could forage within the initial dilution zones where elevated Se in the discharge could contaminate prey species or other dietary items. For the Delta smelt and Central Valley chinook salmon and steelhead, portions of the Delta in the vicinity of the proposed outfall locations have also been formally designated by the Service and National Marine Fisheries Service (NMFS) as Critical Habitat, thus requiring special consideration in avoiding adverse modifications to the species' habitat.

In total, 73 acres of sensitive habitats could potentially be affected by the Delta-Chipps Island Disposal Alternative, and 120 acres could potentially be affected by the Delta-Carquinez Strait Disposal Alternative.

6.2.3 In-Valley Disposal Alternative

Implementation of this alternative would result in temporary and permanent impacts to **terrestrial resources** such as areas of active and retired agricultural lands and other previously disturbed sites. Because disposal features would almost certainly be located on active or retired agricultural lands, direct destruction of undisturbed natural habitats would be unlikely. For retired lands, conversion to a cropping pattern appropriate to the reuse facilities would result in variable effects, depending on the condition and current management of the acquired lands.

Construction of this alternative's potential 5,063 acres of Se-contaminated evaporation ponds would create two large areas of hazardous, low habitat value **wetlands** that previously did not exist in the valley. Construction of the evaporation ponds would be considered a significant effect due to their potential adverse effects on breeding, foraging, and resting migratory waterfowl and that may occur to a limited number of special-status species that may use the sites. To reduce the potential adverse effects, design and management strategies would be implemented, including keeping water levels at 4 feet or greater and maintaining steep sideslopes to eliminate waterfowl and shorebird foraging habitat; controlling emergent and shoreline vegetation; hazing during breeding seasons; avoiding islands, windbreaks and sandbars; and initiating a long-term waterbird monitoring program. Closure of the evaporation ponds at the end of their expected 50-year life would require contouring, capping, revegetating, and monitoring the sites to ensure that seeps and surface water ponding would not create hazardous wetlands.

Operation of the evaporation ponds would also likely require **construction of alternative habitat**, as required under protocols developed by the Service to mitigate for impacts to waterfowl and shorebirds protected under the Migratory Bird Treaty Act. As currently envisioned, the adverse effects of the 5,063 acres of evaporation ponds would be partially offset by construction of 3,200 to 6,400 acres of mitigation lands (alternative habitat), half or more of which would be developed into managed wetland habitats. Successfully creating wetland complexes of the size required to mitigate for the project's evaporation basins would be a challenge. An extensive monitoring program would need to be developed to ensure that the desired results are attained or that mechanisms (including adequate funding) are in place to correct any undesirable outcomes.

While the amount of land that would be occupied by this alternative's potential features is quite large, the probability of significant unavoidable impacts to large numbers of listed **special-status species** would likely be quite small. Ten special-status species could be affected to varying degrees as a result of construction and implementation of the In-Valley Disposal Alternative. The probable level of impact to any of the 10 species would likely be less-than-significant if standard protocols and mitigation measures designed to avoid or protect the species were to be fully implemented.

6.3 GEOLOGY

This section summarizes the geologic conditions and hazards that may be encountered during the construction and implementation of the alternatives for the San Luis Drainage Feature Re-evaluation. A more detailed description of the geologic conditions and hazards is included in Appendix G3.

6.3.1 Ocean Disposal Alternative

The potential route for this alternative through the Coast Ranges crosses several major **fault zones** including the San Andreas, Riconada, and Nacimento faults. In addition, the potential alignment also crosses several smaller faults. Of the three major fault zones identified, the San Andreas is listed as the only currently active fault zone (displacement occurring within the last 200 years). Significant displacement along the San Andreas fault zone could cause the PVC-constructed aqueduct for this alternative to fail. The San Andreas fault has accounted for several intense ground accelerations associated with earthquakes in the Parkfield, California area (approximately 10 miles north of the potential route). Regarding the smaller faults identified along the potential route, it is unlikely that any of the 14 faults identified could cause a major disruption of this route. The potential for intense ground accelerations associated with earthquakes in the southern Coast Ranges would likely require significant engineering measures for the construction of this alternative. The engineering measures would take into account the 1- to 2-centimeter creep that occurs along the San Andreas fault zone on a yearly basis.

In addition, this alternative's route would cross the Franciscan Formation between the edge of Kettleman Hills and Cottonwood Pass, and from near the summit of the Santa Lucia Range to the Pacific Ocean. The Franciscan Formation is susceptible to **landslides** and accounts for the majority of rock and soil material that is sent downslope during landslide events in the Coast Ranges. Significant geotechnical studies, including slope stability, and soil compaction characteristics, would have to be conducted for the pump stations on this route, especially if the locations of the pump stations are on a slope.

6.3.2 Delta Disposal Alternatives

The Delta Disposal Alternatives should not be impacted by **land subsidence** since hydrocompaction and pore space compaction mostly occurs south of the Los Banos, California area.

The potential conveyance does not appear to cross any major **fault lines** identified within the central San Joaquin Valley. However, the conveyance trends roughly parallel to the San Andreas fault system located between 40 and 60 miles to the west. The possibility exists that a sizeable earthquake associated with the San Andreas fault could disrupt the Delta Disposal Alternatives' aqueduct. However, the 1989 Loma Prieta earthquake did not appear to impact the California Aqueduct in a significant manner, which is located near the Delta Disposal Alternatives' potential route. Engineering methods and procedures have improved and are more stringent than when the California Aqueduct was constructed. Therefore, it is unlikely that the potential aqueduct would be significantly affected by an earthquake. Along northern San Joaquin Valley near the Delta, the potential alignment appears to be located approximately 10 miles east of the Greenville fault zone, which trends northwest through the city of Livermore and has segments along the fault that are considered active. The potential route does not cross the Greenville fault zone, but could be impacted or disrupted by any intense ground accelerations caused by earthquakes associated with the Greenville Fault. However, this scenario is unlikely, since only a small portion of the fault (approximately 4 miles long) has shown measurable displacement within the last 200 years.

The Delta-Chipps Island Disposal Alternative's alignment does not appear to cross any other major fault zones. However, the Delta-Carquinez Strait Disposal Alternative's route would cross the Concord fault, which is an active segment of the Greenville fault zone and appears to extend beneath the Delta and beyond to the north. Recent studies of the fault indicate that the fault has caused approximately 65 feet of offset in the last 6,000 years. This amount of offset is unlikely to cause a significant impact to the Delta-Carquinez Strait Disposal Alternative's pipeline. However, engineering measures should be conducted prior to construction to ensure that the yearly creep will not impact the pipeline over a 10- or 20-year period, depending on the estimated life of the pipeline. No evidence exists of catastrophic ground rupture associated with the Concord fault.

6.3.3 In-Valley Disposal Alternative

Two types of **land subsidence** could affect this alternative: pore space compaction and hydrocompaction. Land subsidence could change the grade of the potential aqueduct, which will be used to convey the water to the reuse facilities. In-depth geotechnical investigations would likely be required along the potential conveyance alignment for this alternative to evaluate the potential for subsidence of these sediments prior to the construction. In addition, topographic data could be used in connection with USGS historical benchmark data to determine the amount of subsidence in areas along the potential route and near the reuse facilities. The potential alignment should not be influenced by the oil extraction land subsidence, since it mostly occurs in southern San Joaquin Valley near Bakersfield.

6.4 ENERGY RESOURCES

For all disposal alternatives, the **energy requirements** associated with construction activities would be temporary and are not expected to exert a significant strain on the regional supply of liquid fuels (see Appendix G4). Energy required during the operating period of the project is expected to increase the overall base-load power consumption within the study area for all alternatives. Although the overall incremental change in energy requirements from the operation of all alternatives is not expected to have a significant impact on the power supplies in the region, the added demand would be measurable and advanced planning would be required.

6.5 AIR QUALITY

All disposal alternatives would have an adverse impact on the regional air quality (see Appendix G5). At a minimum, all alternatives will require some type of construction, resulting in temporary construction related air emissions. Additionally, increased power generation and water treatment activities will likely have a more sustained, though regulated impact on regional air quality.

6.6 AGRICULTURAL PRODUCTION AND ECONOMICS

The objectives of providing drainage service are to maintain long-term agricultural productivity and to reduce the accumulation of salts in the soil and groundwater. This section provides a summary of how the drainage service alternatives accomplish the objectives. The following evaluation criteria are addressed:

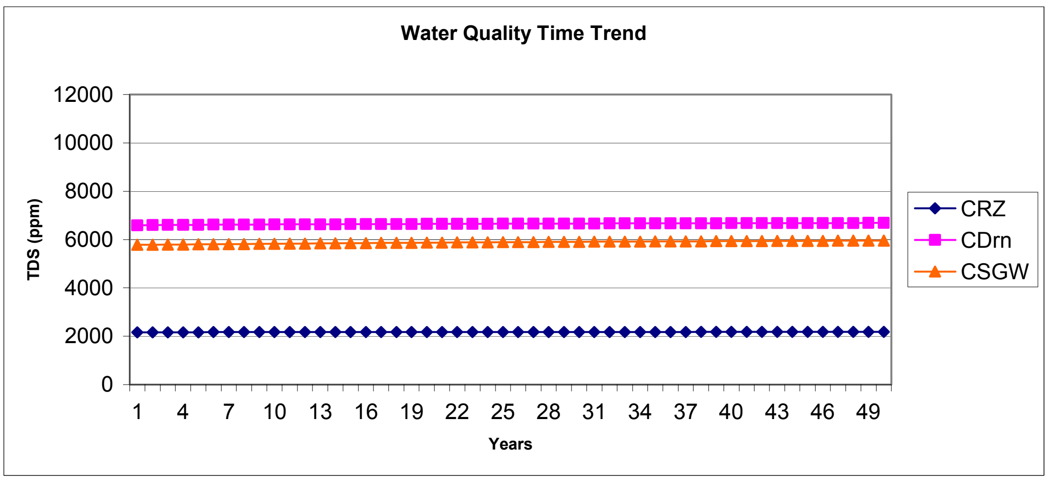
- Volume and salinity (TDS) of drainage collected
- Salinity of the crop root zone, defined for analytical purposes as the top 6 feet of soil;
- Salinity of shallow groundwater
- Overall salt balance in the drainage-affected area
- Crop acres in production
- Potential crop yields and revenues as determined or limited by soil salinity
- Farm-level costs of irrigation and salinity management

Differences among alternatives focus on disposal approaches. The two major alternatives configurations, Out-of-Valley Disposal and In-Valley Disposal, provide the same level of drainage service to the Unit. Their potential impacts on agricultural production and economics differ only because of the irrigated land converted for use by the treatment, disposal, and conveyance facilities or converted to non-agricultural use for mitigation purposes. Importantly, both configurations incorporate the same assumptions for drainwater reduction. As a result, the analysis of impacts is almost identical for the alternatives. The only difference is the number of acres over which to aggregate impacts. The following results are described once, but apply to all of the drainage service alternatives. The important analytical comparisons occur between the No Action Alternative and any of the action alternatives (see Appendix G6).

A modeling approach developed for this study assesses how drainage conditions under different alternatives affect root zone salinity, crop yields, crop production costs, and drainage quantity and quality (see Appendix G6). The findings of the modeling exercises are summarized below for the Northerly and Westlands subareas.

6.6.1 Modeling Results

Drainage service provided to the Northerly Area under any of the action alternatives results in relatively stable drainage and salinity conditions over the 50-year planning horizon. Figure 6.6-1 displays the estimated average soil, drainage, and shallow groundwater salinity for drained fields in the Northerly Area.



CRZ=Concentration of salts in the root zone (ppm TDS of saturation extract)

CDrn=Concentration of salts in drainwater or potential drainwater (ppm TDS)

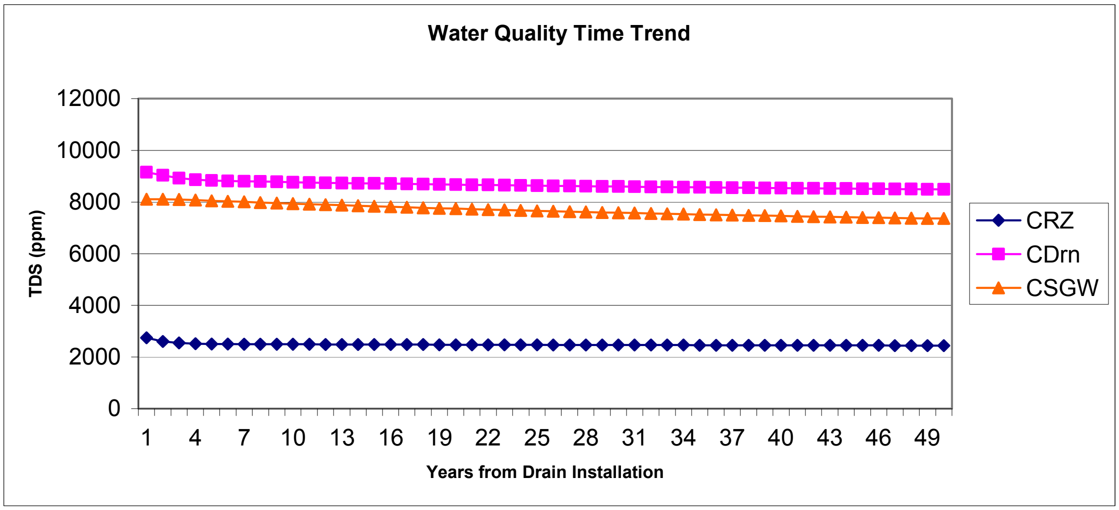
CSGW=Concentration of salts in shallow groundwater (ppm TDS)

Figure 6.6-1 Salinity Trends in the Northerly Subarea, All Drainage Service Alternatives

Soil salinity is estimated to be stable at an average electrical conductivity (EC) of about 3.1 decaSiemens per meter (dS/m). Virtually all crops, except the most salt-sensitive trees, vines, and row crops, can be grown under these conditions. Because this is an estimate of average salinity, some lands can likely be maintained at lower salinity, allowing an even wider range of crops. Undrained lands within the drainage-affected area are also estimated to have relatively stable, though somewhat higher, soil salinity. Overall seasonal water application efficiency in the Northerly subarea is projected to average about 73 percent, though specific estimates can vary significantly across districts, crops, and growing conditions. The trend in drainage, soil, and shallow groundwater salinity in the reuse facility was also modeled. Soil salinity is estimated to be at an EC of about 8.5 dS/m. Very salt-tolerant crops must be used to provide sufficient water use under such saline conditions.

Drainage service provided to lands in the Westlands subareas under any of the action alternatives results in relatively rapid improvement in soil conditions and a more gradual improvement in shallow groundwater and drainage salinity. Figure 6.6-2 shows the trend in salinity conditions for a particular field following drain installation. The figure shows estimates for the Westlands North subarea; results are similar for the other two drainage-affected subareas in Westlands.

Drainage service provided to the Westlands subareas under any of the action alternatives is scaled in over time. The overall drainage quantity and quality estimates are derived by identifying the acreage of new drain installation each year and then aggregating the overlapping series of quantity and quality estimates over the 50-year planning horizon.



CRZ=Concentration of salts in the root zone (ppm TDS of saturation extract)

CDrn=Concentration of salts in drainwater or potential drainwater (ppm TDS)

CSGW=Concentration of salts in shallow groundwater (ppm TDS)

Figure 6.6-2 Salinity Trends for a Typical Drained Field in the Westlands North Subarea, All Drainage Service Alternatives

Soil salinity is estimated to be stable at an average EC of about 3.5 dS/m. Most crops, except salt-sensitive trees, vines, and row crops, can be grown under these conditions. Because this is an estimate of average salinity, some lands can likely be maintained at lower salinity, allowing an even wider range of crops. Undrained lands within the drainage-affected area are also estimated to have relatively stable, though somewhat higher, soil salinity. After all planned drainage installation, the overall seasonal water application efficiency in the Westlands North subarea is projected to average about 78 percent, though specific estimates can vary significantly across crops and growing conditions.

As for the Northerly Area, the trend in drainage, soil, and shallow groundwater salinity in the reuse facility serving the Westlands North subarea was modeled (results for other Westlands reuse facilities would be similar). The soil salinity estimated for later years corresponds to an EC of about 11.5 dS/m. Very salt-tolerant crops must be used to provide sufficient water use under such saline conditions.

6.6.2 Summary of Productivity Impacts for All Alternatives

The objectives of providing drainage service are to maintain long-term agricultural productivity and to reduce the accumulation of salts in the soil and groundwater. This section provides a summary of how the drainage service alternatives accomplish the objectives for all alternatives.

Soil Salinity is measured as the EC of a soil saturation extract. Electrical conductivity provides an estimate of how crop yields may be affected by soil and salinity, therefore, can be used to assess the cropping mix and flexibility possible under the alternatives. All of the changes from No Action to an action alternative are considered significantly beneficial to crop production.

Long-Term Salt Balance is defined for evaluation purposes as the net change in mass of salts in the root zone and shallow groundwater, relative to the No Action Alternative. For both the Out-of-Valley and In-Valley Disposal Alternatives, salt balance is significantly improved in all subareas. In all but one case the salt balance, as estimated here, is positive (net removal) by the year 2050.

Long-Term Yield Impacts are based on crop yield relationships formalized by Maas and Hoffman (see, for example, United Nations 1985). They estimated crop yield impacts caused by average soil salinity over the growing season. There are more crops that are judged to be feasible to grow under the soil and drainage conditions provided by alternatives. A crop is judged feasible if its yield potential is at least 85 percent of what is considered normal for the San Joaquin Valley under nonsaline conditions. Feasible crops with drainage service are cotton, grains, sugar beets, alfalfa, tomatoes, most vegetables and field crops.

6.7 LAND USE

This section evaluates the action alternatives for adverse effects on two types of land use: recreation and agricultural. Recreation in the Central Valley portion of the study area consists mainly of wildlife viewing and hunting in wildlife refuges or wildlife management areas. Most recreation activities associated with these areas are associated with the presence of waterfowl and upland game. Most of the lands are suitable for growing many crops. The Westlands Water District area contains more than 400,000 acres suitable for growing any crop and about 200,000 acres suitable for only salt-tolerant crops. About 5,000 acres of land appear idle because of salinity and drainage problems; some of these lands probably were never reclaimed from native conditions. A more detailed preliminary impact analysis of biological resources is included in Appendix G7.

6.7.1 Ocean Disposal Alternative

Features of this alternative do not cross through any recreation areas. The potential pipeline alignment would follow existing roads as much as possible and avoid existing recreation areas, so no adverse effects on recreation would occur.

At Point Estero, the pipeline would be either buried or suspended from the sea floor approximately 1.5 miles out into the Pacific Ocean. Then, the drainage would be released into the water 200 feet below sea level. Although ocean-based recreation occurs in the area, including sea kayaking, surfing, and deep sea fishing, it is very unlikely that diffusing of the drainwater would be noticed. Thus, no adverse effect to recreation would occur nor would additional recreation facilities need to be constructed.

Under this alternative, the drainage conditions would improve significantly, and agricultural production would gradually increase.

6.7.2 Delta-Chipps Island Disposal Alternative

The first section of the new alignment would consist of closed pipeline; thus, no further attraction for wildlife contributing to an increase in recreation would occur. Several recreation areas are located in the vicinity of the rest of the route (up to Pittsburg), but this alternative does not cross through any of these recreation areas.

At Pittsburg, this alternative continues as closed pipeline along the edge of a power plant to the Delta. There, the buried pipeline extends approximately 1 mile into the Delta. Although water-based recreation, such as fishing and water-skiing, is very popular in the Delta, the buried pipeline would not affect these uses past the construction period. The existing power plant is already in an industrial area where recreation is limited. No impact to recreation would occur nor would any additional recreation facilities need to be constructed due to this alternative.

Under this alternative, the drainage conditions would improve significantly, and agricultural production would gradually increase.

6.7.3 Delta-Carquinez Strait Disposal Alternative

This alternative follows exactly the same route and has the same reuse and treatment facilities as the Delta-Chipps Island Disposal Alternative to the Pittsburg area. There, the Delta-Carquinez Strait Disposal Alternative continues as closed pipeline. The route first follows the Southern Pacific and AT&SF rail lines to Concord Naval Weapons Station. Then, the route follows the Southern Pacific rail line to Martinez, along Martinez Waterfront Regional Shoreline, past Port Costa, to Crockett. Although this conveyance is right along the shoreline and passes through Martinez Waterfront Regional Shoreline, the route follows the existing rail line the entire way. Thus, existing recreation would not be affected by this alternative.

Under this alternative, the drainage conditions would improve significantly, and agricultural production would gradually increase.

6.7.4 In-Valley Disposal Alternative

The evaporation ponds have the potential to be attractive to wildlife. To protect wildlife from the salts and Se accumulating in these areas, the ponds' design and location would be as unattractive to birds as possible (see Section 6.2.3). The possible general location of the northern evaporation pond is west of Tranquility, and the approximate location of the southern pond is west of Lemoore Naval Air Station, although specific sites have not been selected. Both of these areas are unpopulated and are far south of the wildlife refuges and management areas.

With the creation of the evaporation ponds there would be construction of 3,000 to 6,000 acres of alternative habitat for mitigation, much of which would be developed into managed wetland habitats. It is possible that some of the waterfowl currently using known wildlife refuges or duck clubs could use these newly created wetlands, and they could be located near existing refugees or wildlife management areas. However, the future management of these mitigation lands is uncertain, and it may be that they could be managed for recreation, such as hunting or wildlife viewing such as are current refuges. Thus, it is anticipated that recreation would not increase with this alternative. Although the location of recreation use might shift, overall recreation in the area would be unaffected.

Under this alternative, drainage conditions would improve, but some lands would be taken out of production to locate the evaporation ponds and associated mitigation facilities. Agricultural productivity would improve but not as significantly as with the out-of-valley alternatives.

6.8 AESTHETICS

This section summarizes the preliminary comparative impacts of the alternatives on aesthetics or visual resources (see Appendix G8). Aesthetic impacts are evaluated through an examination of the alternative's effects on the visual character of a site (or area) and related viewsheds. Visual character is comprised of a combination of elements, including land use, architecture, design, and building height and/or mass. The visual character of a project site is typically evaluated both to the exclusivity of surrounding land uses and within the context of its neighborhood. It is recognized, however, that issues relating to visual character and the degree of associated environmental impacts are inherently subjective due to the wide range of possible opinions regarding aesthetic values and qualities.

6.8.1 Ocean Disposal Alternative

Visual effects associated with installation of the drainwater conveyance system are likely to be moderate and permanent. All 10 pumping plants may be visible from surrounding residences and local roads and, depending on their height and bulk, may alter the overall visual character of each location somewhat. Their impact is expected to be moderate only because of their relatively small size and distance from viewing corridors. However, three of the plants may potentially have a greater impact due to the undeveloped nature of the surrounding area and their proximity to the highway corridor. Except in wooded areas intersecting the pipeline corridor, pipeline damage would be restored to pre-construction conditions and visual impacts would be temporary. In wooded areas, trees removed during construction would not be replanted.

6.8.2 Delta Disposal Alternatives

Aesthetic effects anticipated to be associated with each of the major components of the Delta Disposal Alternatives are as follows:

- The adverse effects associated with the Se treatment facilities would be moderate and permanent as they would be visible from ground-level vantage points surrounding the site. The treatment facilities may also be visible from nearby residences and local farm roads and, depending on their height and bulk, may alter the overall visual character of each location somewhat. Their impact is expected to be moderate only because other industrial facilities are likely associated with existing agriculture located within the general vicinity of each site.
- The adverse effects associated with the conveyance system from the northern end of the San Luis Drain to Pittsburg are expected to be moderate and permanent. The conveyance system would either be comprised of a combination of buried pipeline and open canals or comprised entirely of buried pipelines. The portions of the route that could consist of open canals are generally in sparsely populated areas of agricultural or open space land west of the San Joaquin River in Stanislaus and southern San Joaquin counties. Another potential canal segment is in a marginally more densely populated area of eastern Contra Costa and Alameda counties and western San Joaquin County (from Brentwood to Bethany). As other open

canals exist in these areas, selection of the canal option would not be expected to alter the existing visual character of the locale. However, views from some residences along the route could be impacted. If the pipeline option is chosen, impacts would be temporary during construction only. In addition to the linear facilities, two pumping plants would be constructed that may be visible from surrounding residences and local roads and, depending on their height and bulk, may alter the overall visual character of each location somewhat. Their impact is expected to be moderate only because other industrial facilities are likely associated with existing agriculture already located within the general vicinity of each site.

- In addition, for the Delta-Carquinez Strait Disposal Alternative, the adverse effects associated with installation of the buried pipeline segment from Pittsburg to Crockett are expected to be moderate and temporary. Though most of the area along this route is currently industrial and/or commercial, views from some residences in Martinez and Crockett could be impacted during construction. Similarly, views from East Bay Regional Park District lands along Carquinez Strait could be affected during pipeline and outfall construction.

6.8.3 In-Valley Disposal Alternative

Aesthetic effects anticipated to be associated with each of the major components of this alternative are as follows:

- The adverse effects caused by construction and operation of the RO treatment would be moderate and permanent. The RO treatment plant may be visible from surrounding residences and local roads and, depending on its height and bulk, may alter the overall visual character of the location somewhat. The impact is expected to be moderate only because other industrial facilities are likely associated with existing agriculture already located within the general vicinity.
- The adverse effects associated with installation of the drainwater conveyance system are likely to be moderate and permanent. Four pumping plants may be visible from surrounding residences and local roads and, depending on their height and bulk, may alter the overall visual character of each location somewhat. Their impact is expected to be moderate only because other industrial facilities are likely associated with existing agriculture already located within the general vicinity of each site.
- The adverse effects associated with the treatment and disposal facilities would likely be moderate and permanent. Impacts would be permanent as each component would be visible from ground-level vantage points surrounding the sites. The evaporation ponds, treatment reactors, and salt disposal sites may be visible from nearby residences and local farm roads and, depending on their height and bulk, may alter the overall visual character of each location somewhat. Their impact is expected to be moderate only because other industrial facilities are likely associated with existing agriculture and other evaporation ponds already located within the general vicinity of each site.

6.9 SOCIAL ISSUES AND ENVIRONMENTAL JUSTICE

During the planning process, uncertainty, especially for irrigators (e.g., not knowing how to plan for the future for crops, on-farm investments, etc.), was mentioned as a social issue. Uncertainty for all potentially affected people will continue until the project is implemented. Issues identified by the public were considered during alternative formulation. Potential social issues during construction, including employment opportunities, noise, dust, and disruption of traffic are addressed previously in this document or will be addressed in the subsequent EIS.

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks of their decisions. Environmental justice addresses the fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an environmental action.

To comply with the environmental justice policy established by the Secretary, all Interior agencies are to identify and evaluate any anticipated effects, direct or indirect, from the proposed project, action, or decision on minority and low-income populations and communities, including the equity of the distribution of the benefits and risks. Accordingly, Appendix G9 examines the anticipated distributional equity of alternative-associated impacts with respect to potentially affected minority and economically disadvantaged groups.

The immediate study area (Fresno, Kings, and Merced counties) and other counties potentially affected by construction of the alternatives (Kern, Madera, San Joaquin, and Stanislaus) contain high percentages of racial and ethnic minorities and persons and families below the poverty level. Unemployment is significantly higher in these counties than in other areas of the state. Consequently, the potential exists for low-income and minority populations to be disproportionately affected. It is anticipated construction would provide some short-term employment opportunities for minority and low-income individuals.

No human health impacts for any human population have been identified. Thus, an adverse environmental justice impact would not occur. Uses of resources, including support of subsistence living by minority or low-income communities, have not been analyzed. To address potential economic environmental justice impacts at this level of analysis, data from the regional impact analysis is needed. This analysis will be contained in the EIS.

At the next level of analysis, while specific locations of facilities for each alternative are being determined, it will be important to identify local minority and low-income communities to ensure they are not disproportionately adversely affected. At that time, it will also be important to identify the use of affected resources by minority and low-income groups, including whether they support subsistence living. As the economic impacts are refined, the impacts to minority and low-income communities will also need to be addressed.

6.10 CULTURAL RESOURCES

This section summarizes the preliminary impact assessment of major cultural areas that are likely to be affected by construction and operation activities of the action alternatives. This preliminary impact assessment does not focus on effects to individual cultural resources. Instead, generalized cultural resource types are described and impacts to the generalized cultural resources types are assessed in Appendix G10 and summarized here.

The assumption is that all significant cultural resources within the project's Area of Potential Effects (APE) will be adversely affected and that mitigation measures will be required. However, the need for mitigation can be reduced by avoidance during the project planning stages. For this to occur close coordination will be needed between the cultural resource personnel and those planning, preparing, and implementing the project. If avoidance of some cultural resources is possible in an economically and environmentally feasible way, provisions for their continued avoidance and periodic review would be written into the Programmatic Agreement and the Historic Property Management Plan.

6.10.1 Ocean Disposal Alternative

Implementation of the Ocean Disposal Alternative could result in adverse effects on cultural resources. These effects could result from construction of the aqueduct, tunnel portals, and pumping plants. Reuse facilities (common to all alternatives) would be developed; this development could have adverse effects on historic properties. An unspecified amount of land would also be disturbed for temporary access/haul roads, staging areas, and disposal of excavated materials from tunnel boring and pipeline construction. All of these activities could have an adverse effect on historic properties. Construction of the extensive network of canals, pipelines, and drains to collect and convey drainwater to reuse facilities could also have direct adverse effects on cultural resources.

No specific cultural resource studies have been completed for this alternative. Surveys have been completed for the segment of the alignment that crosses Sunflower Valley and along the coast at Point Estero. Both areas have archeological sites that may be eligible for listing on the National Register of Historic Places.

Prehistoric archeological sites are common along southern Coast Range drainages and coastal areas. Sites include villages, camps, lithic scatters, and food processing areas. Cemeteries were generally associated with villages. Early historic sites, mainly related to ranching, also are present. Construction activities are likely to have an adverse effect on cultural resources. Completion of the Class I Records search is pending.

6.10.2 Delta Disposal Alternatives

Implementation of either of the Delta Disposal Alternatives could result in adverse effects on cultural resources. These effects could result from construction of the aqueduct (whether fully or partially piped) and pumping plants. An unspecified amount of land would also be disturbed for use as temporary access/haul roads and construction staging areas. A biological treatment facility would be constructed and four reuse facilities with their associated collection systems (common to all action alternatives) would be developed. All these actions have the potential to have adverse effects on historic properties.

A substantial amount of previous cultural resource inventory work has been conducted within the study limits of alternatives that dispose of drainwater into the Delta. The previous cultural resources studies, conducted between 1980 and 1983, were completed either by contractors for Reclamation or done in-house. The work was conducted in accordance with the requirements of Section 106 of the National Historic Preservation Act (NHPA) and its implementing regulations (36 Code of Federal Regulations [CFR] 800) at that time. Since that time the NHPA and its regulations have been amended and revised (see Appendix G10).

Cultural resource investigations conducted to date for the Delta Disposal Alternatives covered the area from the northern margins of Tulare Lake to the Chipps Island outlet. The study alignment of these past investigations is similar to, though not identical with, the currently proposed alignment. No specific studies have been completed for the alignment and drainage outfalls west of the Chipps Island outlet (Carquinez Strait outlet). In the previous investigations, a literature and records search was conducted and the data tabulated and mapped. Emphasis was placed on the identification of prehistoric and Native American historic age archeological sites, although databases and records for historic properties were also examined. From these data an attempt was made to find relationships between environmental variables (soils, vegetation, or water courses) and prehistoric and Native American historic site locations to determine areas that would be most likely to contain such sites.

Based on past investigations, no previously recorded archeological sites, except those at Kesterson National Wildlife Refuge, fall within the currently proposed alignment. Prehistoric sites primarily occur on just a few soil types along drainages. These sites consist of village sites, camps, and artifact scatters. A number of the village sites are known to contain burials.

Most of the currently proposed alignment and reuse areas have been greatly altered by agricultural activities and few of the natural contours or drainages remain. Only isolated artifacts and artifact scatters were found to fall within the lands examined. No historic properties were found along the Chipps Island conveyance route. A number of historic properties are known to be present near the Carquinez Strait alignment. A records search for this alignment is pending.

6.10.3 In-Valley Disposal Alternative

Implementation of the In-Valley Disposal Alternative could result in adverse impacts to historic properties. Construction of four reuse facilities and associated collection/conveyance systems, pumping facilities, reverse osmosis and biological treatment facilities, two evaporation basins, and two alternative wetland habitat mitigation complexes all have the potential to affect historic properties.

No specific cultural resource studies have been completed for this alternative. Virtually all the lands that would be affected by this alternative have been modified by agricultural practices: leveling, plowing, farm roads, irrigation, and drainage. Most of the conveyance alignments follow existing roads. Scatters of artifacts have been noted for the area. Such scatters are probably the remains of prehistoric archeological sites that have been obliterated by agricultural activities.

While completion of the Class I records search is pending, no known historic properties will be affected by this alternative.

6.11 PUBLIC CONCERN

Reclamation reviewed and evaluated potential public concerns about the final alternatives. Of course, all alternatives (including the No Action Alternative) have features or consequences that cause public concern, some involving over-arching policy issues, others involving local concerns, that might create opposition. At this stage, a discussion of the full range of public concerns regarding drainage service is not presented. Rather, this evaluation assesses, for comparative purposes, the relative level of public concern that might occur for each alternative on five major issues.

6.11.1 Approach

The Public Involvement Work Group identified five major issues of public concern from public input received during this and previous studies. These issues describe issues of interest to a full range of stakeholders (farmers and farming interests, environmental groups, agencies, and water providers) and help distinguish among the alternatives.

- **Source Water Quality** – Does an alternative generate concerns about impacts to fresh water supplies for agricultural or urban use, including groundwater and surface water?
- **Aquatic Resources** – Does an alternative generate concerns about impacts on special or protected aquatic resource areas, water quality, and fisheries or biota?
- **Surface Exposure to Selenium** – Does an alternative generate concerns about exposure of wildlife to selenium from substantial areas of open water?
- **Production Acres Impact** – Does an alternative generate concerns about converting substantial acres of agricultural land for drainage service facilities?
- **Resource Re-Use and Recycling** –Does an alternative result in beneficial re-use or recycling of water or other constituents?

For each disposal concept (Ocean, Delta, and In-Valley), the Project Team assessed whether an issue was a public concern for that concept. This assessment identifies only the likelihood that an alternative would cause concern; it does not represent an actual measure of the acceptability or level of acceptance.

6.11.2 Impact Analysis

The following analysis is organized by the five major issues of public concern.

6.11.2.1 Ocean Alternative

Source Water Quality – The Ocean Alternative is not likely to generate concerns about impacts to source water supplies as there are no drinking water or agricultural water supplies near the discharge location.

Aquatic Resources – The Ocean Alternative would generate substantial public concerns about potential impacts to aquatic resources, particularly concerns about coastal impacts, commercial and recreational fisheries, and protected marine resources.

Surface Exposure to Selenium – Some public concerns would be generated about potential bioaccumulative effects of selenium (and other constituents) on ocean resources.

Production Acres Impact – The Ocean Alternative would not generate public concerns because it would require the fewest acres of productive agricultural land for treatment and disposal facilities.

Resource Re-Use and Recycling – The Ocean Alternative would be perceived as less desirable because it would not include any additional re-use or recycling of water and salts, other than that included in all alternatives.

6.11.2.2 Delta Alternatives

Source Water Quality – The Delta-Chipps Island Alternative would generate substantial public concern about the potential impacts of the discharge on drinking water supplies from the Delta. The Delta-Carquinez Strait Alternative would generate similar concerns, to a lesser degree because the discharge point is farther from drinking water intakes.

Aquatic Resources – Both Delta Alternatives would create substantial public concerns about impacts to aquatic resources in the Delta, including Suisun Marsh.

Surface Exposure to Selenium – Both Delta Alternatives would generate concerns about potential exposure of wildlife to selenium. Concerns would be slightly greater for the Delta-Chipps Island Alternative because of its proximity to freshwater biological resources and habitat.

Production Acres Impact – The Delta Alternatives would not generate public concerns because they would require few acres of productive agricultural land (fewer than 200) for treatment and disposal facilities.

Resource Re-Use and Recycling – The Delta Alternatives would be perceived as less desirable because they would not include any additional re-use or recycling of water and salts, other than that included in all alternatives.

6.11.2.3 In-Valley Alternative

Source Water Quality – The In-Valley Alternative is not likely to generate concerns about impacts to source water supplies because the treatment facilities and evaporation ponds would be located in areas where groundwater is not potable.

Aquatic Resources – The In-Valley Alternative would not generate any public concerns about potential impacts to aquatic resources because there would be no surface water discharges to water bodies.

Surface Exposure to Selenium – The In-Valley Alternative would generate substantial public concerns about potential surface exposure to selenium due to the large areas of evaporation ponds.

Production Acres Impact – The In-Valley Alternative could generate public concerns because it would require conversion of approximately 8,400 to 11,600 acres of agricultural land for treatment, disposal, and mitigation facilities.

Re-Use and Recycling – The In-Valley Alternative could be perceived as more desirable because it would include reverse osmosis treatment to recover and re-use some of the drainwater. This alternative also allows for re-use of salts if a market for them develops in the future.

6.11.3 Summary and Conclusion

Reclamation determined that while all alternatives would result in public concerns, the In-Valley Alternative is likely to generate the fewest concerns. The Delta Alternatives would generate the greatest public concern. These conclusions are based on the discussion above and in Appendix H, as well as the general belief that managing the drainwater problem where it is generated is a concept acceptable to all of the affected interests.

SECTIONSEVEN

SELECTION OF PROPOSED ACTION

This section describes the process for selecting the proposed action from the four action alternatives described in Section 5. The results of the evaluation process are summarized herein with additional supporting material provided in Appendix H, Screening for the Proposed Action.

Based on the results of the preliminary impact analysis, Reclamation evaluated and compared the alternatives in five major categories to identify the proposed action. These categories (or screening criteria) were cost, time to implement, implementation complexity (including flexibility to adapt to changing conditions and permitting complexity), environmental effects and risks (including land and water resource impacts and public health), and public concern.

Table 7-1 summarizes the results of the evaluation process in October 2002 using scores ranging from 1 (worst) to 5 (best). All of the values represent scores except for cost, which is an actual value. Costs have been updated to reflect the estimates contained in Table 5.6-1.

Table 7-1
Comparison of Alternatives

Evaluation Factors	Alternatives			
	In-Valley Disposal	Delta-Chipps Island Disposal	Delta-Carquinez Strait Disposal	Ocean Disposal
Cost (Total Present Worth, $ millions)	946	1,006	1,079	1,183
Time to Implement	5	3	3	2
Implementation Complexity				
Permitting Complexity	4	1	2	3
Flexibility	5	1.5	2.5	4
Environmental Effects & Risks	3.9	2.7	2.7	3.7
Land Impacts	4.2	3	2.5	3.5
Drinking Water	5	2	3	5
Salts Disposal	3	2	3	5
Selenium Exposure	2	1	2	4
Hazards	4	3.3	3.3	2.8
Public Concern	3	1.4	1.8	2.8

7.1 EVALUATION PROCESS AND CRITERIA

Reclamation used an evaluation process to select the proposed action alternative from the disposal options developed from the initial screening process described in Section 4.2 and Appendix C, Preliminary Screening of Alternatives. The initial screening criteria (and factors associated with the criteria) and the evaluation scales (natural and constructed values) used in June 2002 were refined for this process. The process focused on criteria that clearly distinguished among disposal alternatives. As part of the process, technical team members reviewed the specific criteria with the management team. Then the team members applied the criteria and made preliminary recommendations on scores, which were subsequently reviewed and confirmed by the management team. The following criteria and screening factors were used in October 2002 to select the proposed action:

1. Cost
   1A Annual equivalent costs
   1B Construction costs
   1C Discounted value of construction and interest during construction (IDC)
   1D Discounted value of annual operations, maintenance, replacement, and energy costs
2. Cost Effectiveness
   2B Cost per acre remaining in production
3. Agricultural Productivity
   3A Long-term salt balance
   3B Yield impacts of soil salinity
   3C Agricultural production
4. Time to Implement (time to provide service from 1/1/05)
5. Public Concern
   5A Source water quality
   5B Aquatic resources
   5C Surface exposure to Se
   5D Resource reuse and recycling
   5E Impact to acres in production
6. Legal and Institutional Constraints
   6B Complexity of permitting process
   6C Uncertainty of permitting process
7. Flexibility to Meet Changing Conditions
   7A Potential future regulations
   7B Changes in drainage quantity and quality
8. Land Impacts
   8B Construction impacts:
   8B1 Rare/protected terrestrial habitats and special-status species
   8B2 Urban corridor
   8A Operation impacts:
   8A1 Rare/protected terrestrial habitats and special-status species
   8A2 Urban corridor
9. Risk
   9A Hazards:
   9A1 Earthquake
   9A2 Floods
   9B Environmental:
   9B1 Drinking water supply
   9B2 Salt disposal
   9B3 Potential for wildlife exposure to Se

A description of these criteria and their application is provided in Appendix H.

7.2 SELECTION PROCESS RESULTS

On October 24, 2002, the entire team met to review the individual scores for each alternative and to rank the results. Higher scores indicated a superior alternative. The scores are summarized in the matrix provided as Table 7-2. Key findings for each of the screening criteria/factors are:

(1) Costs

- The In-Valley Disposal Alternative (with lagoon Se treatment) is the least expensive for annual equivalent costs (1A), construction costs (1B), and discounted value of construction and interest during construction (1C). This is due to some of the capital costs occurring later (early costs have a greater impact) but with higher O&M costs over the 50-year time period.
- For Factors 1C and 1D (discounted value of annual operations, maintenance, replacement, and energy), the discounting process includes contingencies to address potential errors and uncertainties.
- For the current level of analysis, the costs are not very different due to the unknowns. Uncertainties contained in the costs at this point include energy, lining of ponds, whether an ocean outfall will need treatment, and the phasing of facilities.

(2) Cost Effectiveness

- The lowest cost per acre remaining in production was calculated at $451 per acre for In-Valley, $484 to $524 for Delta, and $633 for Ocean Disposal Alternatives.
- This cost is based on the acres drained with a difference between In-Valley and Out-of-Valley Disposal Alternatives of about 5,500 acres (less for In-Valley due to acreage taken out of production/not drained for evaporation ponds and mitigation requirements).

(3) Agricultural Productivity

- All of the alternatives provide roughly equivalent levels of drainage service with relatively minor differences occurring because of acreage needed for treatment and disposal facilities.
- Consequently, all provide significant improvement for the three criteria and are scored the same; therefore, these criteria do not help to distinguish between the action alternatives.

(4) Time to Implement

- Officially, overall drainage begins when final disposal is available.
- **The In-Valley Disposal Alternative provides drainage faster than the other two, beginning by October 2010.** This is because partial drainage could start as soon as the reuse area, evaporation ponds, and RO and Se treatment system are in place in the Northerly Area. For In-Valley, only half of the project is completed in the first phase. The second phase, to begin 15 years later, would complete the remaining portions of the project. Completing it in two phases is not expected to constrain any of the farmers from installing drains to ensure an adequate salt balance.

Table 7-2
Screening Criteria/Factors and Scores for Selection of the Proposed Action

		Ocean Disposal	Delta Disposal		In-Valley Disposal
		Point Estero	Chipps Island	Carquinez Strait	
	COST				
1	**Cost**				
1A	Annual Equivalent Costs ($1,000)	$74,026	$56,548	$61,225	$50,288
1B	Construction Costs ($1,000)	$969,262	$812,472	$882,472	$709,142
1C	Discounted Value of Construction, IDC Costs ($1,000)	$911,342	$716,741	$788,885	$589,583
1D	Discounted Value of Annual OM&R and Energy Costs ($1,000)	$235,387	$159,234	$159,544	$189,425
2	**Cost Effectiveness**				
2A	Cost per $ of gross-farm income	NA	NA	NA	NA
2B	Cost per acre remaining in production	$633	$484	$524	$451
3	**Agricultural Productivity**				
3A	Long Term Salt Balance	5	5	5	5
3B	Yield Impacts of Soil Salinity	5	5	5	5
3C	Agricultural Production Costs Avoided by Action	5	5	5	5
	Average Agriculture Productivity	**5**	**5**	**5**	**5**
	IMPLEMENTATION				
4	**Time to Implement**	2	3	3	5
	Estimated Time to Provide Service (from 1/1/05)				
	AVERAGE AGRICULTURE PROD. & TIME TO IMPLEMENT	**3.5**	**4**	**4**	**5**
5	**Public Concern**				
5A	Source Water Quality	5	1	2	4
5B	Aquatic Resources	1	1	1	5
5C	Surface Exposure to Se	5	2	3	1
5D	Resource Re-use and Recycling	1	1	1	4
5E	Impact to Acres in Production	2	2	2	1
	Average Public Concern	**2.8**	**1.4**	**1.8**	**3**
6	**Legal & Institutional Constraints**				
6A	Complexity of Permitting Process	3	1	2	4
6B	Uncertainty of Permitting Process	3	1	1	3
	Average Legal & Institutional Constraints	**3**	**1**	**1.5**	**3.5**
7	**Flexibility to Meet Changing Conditions**				
7A	Potential Future Regulations	5	1	2	5
7B	Changes in Drainage Quantity and Quality	3	2	3	5
	Average Flexibility	**4**	**1.5**	**2.5**	**5**
	AVERAGE PERMITTING AND IMPLEMENTABILITY	**3.5**	**1.25**	**2.0**	**4.3**
	ENVIRONMENTAL IMPACTS				
8	**Land Impacts**				
8B	Construction Impacts				
8B1	*Rare/protected terrestrial habitats and special status species*	2	3	2	4
8B2	*Urban Corridor*	4	3	2	5
8A	Operation Impacts				
8A1	*Rare/protected terrestrial habitats and special status species*	4	3	3	3
8A2	*Urban Corridor*	4	3	3	5
	Average Land Impacts	**3.5**	**3**	**2.5**	**4.25**
9	**Risk**				
9A	Hazards				
9A1	*Earthquake*	2	3	3	4
9A2	*Floods*	3.5	3.5	3.5	4
9B	Environmental				
9B1	*Drinking Water Supply*	5	2	3	5
9B2	*Salt Disposal*	5	2	3	3
9B3	*Potential for Wildlife Exposure to Se*	4	1	2	2
	Average Risk	**3.9**	**2.3**	**2.9**	**3.6**
	AVERAGE ENVIRONMENTAL IMPACTS	**3.7**	**2.65**	**2.7**	**3.925**

- For the Delta and Ocean Disposal Alternatives, construction of the entire conveyance system (pipelines, tunnels, pumping plants, and diffusers) would need to be completed before any drainage begins. The Delta Disposal Alternatives would provide drainage by October 2013 and the Ocean Disposal Alternative would provide drainage by October 2014.

(5) Public Concern

- The purpose of these criteria is to capture part of the political decision-making process by considering key public concerns.
- The top two issues with the public are **water supply/quality** and the **environment**. However, when considering all of the issues, the In-Valley Disposal Alternative scores slightly more positively than does the Ocean Disposal Alternative. The Delta Disposal Alternatives score significantly lower.

(6) Legal and Institutional Constraints

- The number of permits required for the various alternatives is not a distinguishing factor, a difference of only 1 out of 24 permits among the alternatives. Rather, the **complexity of permits** depends upon both the number and types of permits. The In-Valley Disposal Alternative was scored as having a less complex permitting process than the other alternatives.
- The **uncertainty** of obtaining necessary permits includes uncertainty associated with dilution credits for bioaccumulative parameters. Consequently, the Delta Disposal Alternatives were scored as having many questions or requiring approvals from multiple agencies, thus receiving a lower score. The Ocean and In-Valley Disposal Alternatives have some uncertainties about assumptions in permits from one or two agencies and scored higher than the Delta Disposal Alternatives.

(7) Flexibility to Meet Changing Conditions

- **The Ocean and In-Valley Disposal Alternatives have the greatest potential to comply with changes in regulations (i.e., greatest flexibility).** With the In-Valley Disposal Alternatives, there currently are no discharge limits to meet (although substantial mitigation obligations are required). Regulatory changes could result in the need to re-negotiate mitigation obligations. The Delta Disposal Alternatives would have minimum flexibility to meet more stringent future requirements.
- Concerning the flexibility to adjust treatment or disposal facilities to adapt to changes in drainage quantity or quality, the **In-Valley Disposal Alternative is the most flexible** because components can be added. The Ocean Disposal Alternative can accommodate potential changes to drainage quality, but the Delta Disposal Alternatives is the least flexible, as changes in quantity or quality could result in inability to meet load-based standards.

(8) Land Impacts

- Significant **construction impacts to rare/protected terrestrial habitats and special status species** are less likely for the In-Valley Disposal Alternative than for the Delta and Ocean Disposal Alternatives because all In-Valley facilities would be sited in agricultural lands and other previously disturbed habitat types. The Delta and Ocean Disposal Alternatives would each require pipeline construction in native habitat types, possibly affecting a number of protected terrestrial species and habitat types. The Ocean and Delta-Carquinez Strait Disposal Alternatives present the highest potential for impacts. Construction in habitats that potentially could support certain protected species could result in temporary work stoppages or redesigns.

- **Construction impacts to the urban corridor** based on the density of development and extent of area affected is less disruptive for In-Valley and Ocean Disposal Alternatives than for the Delta Disposal Alternatives.
- **Operational impacts to rare/protected terrestrial habitats and special status species** under all alternatives would be limited, generally less-than-significant, and would be unlikely to result in situations that would require curtailment or interruption of normal day-to-day operations (Note: Operational impacts, e.g., operation of evaporation ponds, would be more likely to impact *aquatic* and *wetland* species/habitats than terrestrial species/habitats). Normal operation of the Ocean Disposal Alternative, which consists primarily of buried conveyance structures, presents little chance of significantly impacting protected terrestrial resources. The Delta and In-Valley Disposal Alternatives, with substantial surface features (evaporation ponds, open canals, treatment lagoons, etc.), present a slightly higher probability of impacting terrestrial special status species.
- **Operational impacts to the urban corridor** would not be significant for the In-Valley Disposal Alternative in comparison to the other alternatives because residential uses would not be affected by noise from pump operation.

(9) Risk

Hazards

- Of the alternatives, the In-Valley Disposal Alternative has the lowest probability of being subjected to moderate to large **earthquake ground motions** over the life of the project. No known active faults underlie any project feature.
- All of the alternatives have similar scores for potential adverse environmental impacts due to **flooding**, but In-Valley scores slightly higher than the Ocean and Delta Disposal Alternatives. Failure could cause a release of contaminated material into floodwaters, but the flood flows would also dilute any potential release. Facilities can be designed to handle the flood hazard.

Environmental

- Probable and perceived risks to both groundwater and surface **drinking water supplies** were evaluated by reviewing the modeling results and location of known drinking water intakes. The Ocean Disposal Alternative scored high because the discharge point would not be located in proximity to any drinking water supplies.
- The In-Valley Disposal Alternative also scored high because no discharges are planned that could impact drinking water supplies. Chipps Island was scored lowest based on the perceived risk to drinking water intakes in the Delta. Carquinez Strait scored slightly higher than Chipps Island based on the water quality modeling which shows a lower TDS contribution to drinking water intakes.

- Concerning **salt disposal**, the Ocean Disposal Alternative scored highest because salt is permanently removed from the San Joaquin Valley. For the Delta Disposal Alternatives, some salt comes back to the valley due to operation of the pumps. For the In-Valley Disposal Alternative, salt is removed from the water table, although it remains in the evaporation ponds and not removed from the valley.
- Concerning the **potential for exposing aquatic and terrestrial wildlife** to unsafe concentrations of selenium and the resulting effects of Se bioaccumulation, the Ocean Disposal Alternative has the least potential risk. Elevated Se at In-Valley evaporation facilities would be a potential exposure pathway; Reclamation estimated mitigation measures to offset this potential effect. Based on the near-field modeling results, discharges into the Delta have a potential to cause bioaccumulation.

The factor scores on the matrix were averaged to produce scores for each group of criteria, and these are shown on Table 7-2. **The In-Valley Disposal Alternative ranked first/highest for the following perspectives: cost, time to implement, public concern, permitting, and environmental issues. As a result, Reclamation selected the In-Valley Disposal Alternative as the proposed action for providing drainage management service to the study area**. Additional information on the In-Valley Disposal Alternative is provided in Appendix I.

7.3 NEXT STEPS

This Plan Formulation Report is being distributed for public review and comment in December 2002. Interested agencies, organizations, and individuals will have an opportunity to comment on the recommended proposed action and the other reasonable alternatives described and evaluated herein. These comments may affect the determination of the No Action and Action Alternatives to be covered in the EIS.

Starting in January 2003, Reclamation will proceed to prepare an EIS based on the information contained herein, any public comments, and additional technical analyses to resolve uncertainties and to investigate potential environmental impacts. A Draft EIS is planned for release for public comment in June 2004. The Final EIS is to be completed by June 2005. Work on the anticipated permits for the In-Valley Alternative will be initiated in January 2003 due to the long lead time required for permitting such a complex project and the need to provide prompt drainage service.

SECTIONEIGHT

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